RQF LEVEL 3

CSACI301

COMPUTER SYSTEM AND ARCHITECTURE

Electronic Circuit Implementation

TRAINEE'S MANUAL

October, 2024

ELECTRONIC CIRCUIT IMPLEMENTATION

2024

AUTHOR'S NOTE PAGE (COPYRIGHT)

The competent development body of this manual is Rwanda TVET Board ©, reproduce with permission.

All rights reserved.

- This work has been produced initially with the Rwanda TVET Board with the support from KOICA through TQUM Project
- This work has copyright, but permission is given to all the Administrative and Academic Staff of the RTB and TVET Schools to make copies by photocopying or other duplicating processes for use at their own workplaces.
- This permission does not extend to making of copies for use outside the immediate environment for which they are made, nor making copies for hire or resale to third parties.
- The views expressed in this version of the work do not necessarily represent the views of RTB. The competent body does not give warranty nor accept any liability
- RTB owns the copyright to the trainee and trainer's manuals. Training providers may reproduce these training manuals in part or in full for training purposes only. Acknowledgment of RTB copyright must be included on any reproductions. Any other use of the manuals must be referred to the RTB.

© Rwanda TVET Board

Copies available from:

- *HQs: Rwanda TVET Board-RTB*
- *Web: www.rtb.gov.rw*
- **KIGALI-RWANDA**

Original published version: October 2024

ACKNOWLEDGEMENTS

The publisher would like to thank the following for their assistance in the elaboration of this training manual:

Rwanda TVET Board (RTB) extends its appreciation to all parties who contributed to the development of the trainer's and trainee's manuals for the TVET Certificate III in Computer system and architecture, specifically for the module **"CSACI301: Electronic Circuit Implementation** "We extend our gratitude to KOICA Rwanda for its contribution to the development of these training manuals and for its ongoing support of the TVET system in Rwanda

We extend our gratitude to the TQUM Project for its financial and technical support in the development of these training manuals.

We would also like to acknowledge the valuable contributions of all TVET trainers and industry practitioners in the development of this training manual.

The management of Rwanda TVET Board extends its appreciation to both its staff and the staff of the TQUM Project for their efforts in coordinating these activities.

This training manual was developed:

Under Rwanda TVET Board (RTB) guiding policies and directives

Under Financial and Technical support of

COORDINATION TEAM

RWAMASIRABO Aimable

MARIA Bernadette M. Ramos

MUTIJIMA Asher Emmanuel

PRODUCTION TEAM

Authoring and Review

IMENA MAKUZA Patrick

IRANKUNDA Innocent

Validation

TWIZERIMANA NYABYENDA Jackson

AHIMANA Jean Marie Vianney

Conception, Adaptation and Editorial works

HATEGEKIMANA Olivier

GANZA Jean Francois Regis

HARELIMANA Wilson

NZABIRINDA Aimable

DUKUZIMANA Therese

NIYONKURU Sylvestre

KWIZERA INGABIRE Diane

Formatting, Graphics, Illustrations, and infographics

YEONWOO Choe

SUA Lim

SAEM Lee

SOYEON Kim

WONYEONG Jeong

HAKIZAYEZU Adrien

Financial and Technical support

KOICA through TQUM Project

TABLE OF CONTENT

ACRONYMS

AC: Alternating Current

ADC: Analog-to-Digital Converter

BJT: Bipolar Junction Transistor

CAD: Computer-Aided Design

DC: Direct Current

EDA: Electronic Design Automation

ESD: Electrostatic Discharge

GND: Ground

IC: Integrated Circuit

LED: Light Emitting Diode

MOSFET: Metal-Oxide-Semiconductor Field-Effect Transistor

PCB: Printed Circuit Board

PWM: Pulse Width Modulation

RMS: Root Mean Square

RTB: Rwanda TVET Board

SMD: Surface-Mount Device

SPICE: Simulation Program with Integrated Circuit Emphasis

TQUM: TVET Quality Management

USB: Universal Serial Bus

VCC: Voltage Common Collector (positive supply voltage)

VLSI: Very Large Scale Integration

INTRODUCTION

This trainee's manual includes all the knowledge and skills required in computer system and architecture specifically for the module of **"Electronic Circuit Implementation".** Trainees enrolled in this module will engage in practical activities designed to develop and enhance their competencies. The development of this training manual followed the Competency-Based Training and Assessment (CBT/A) approach, offering ample practical opportunities that mirror real-life situations.

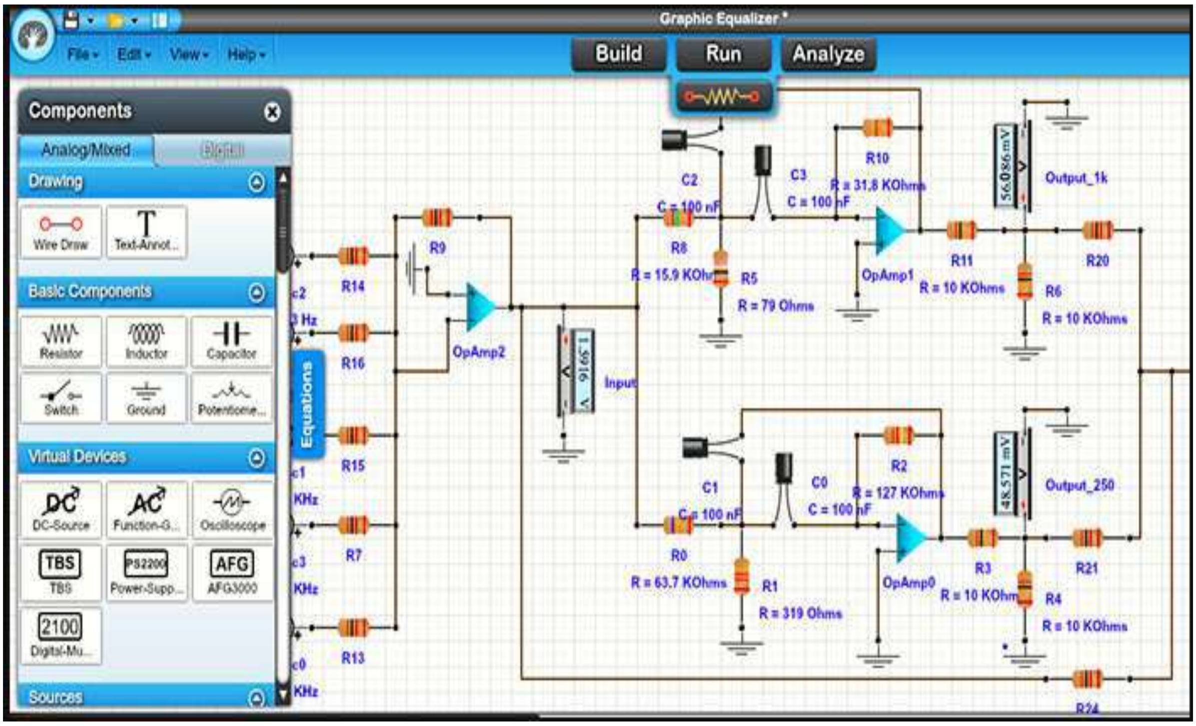
The trainee's manual is organized into Learning Outcomes, which is broken down into indicative content that includes both theoretical and practical activities. It provides detailed information on the key competencies required for each learning outcome, along with the objectives to be achieved.

As a trainee, you will start by addressing questions related to the activities, which are designed to foster critical thinking and guide you towards practical applications in the labor market. The manual also provides essential information, including learning hours, required materials, and key tasks to complete throughout the learning process.

All activities included in this training manual are designed to facilitate both individual and group work. After completing the activities, you will conduct a formative assessment, referred to as the end learning outcome assessment. Ensure that you thoroughly review the key readings and the 'Points to Remember' section.

MODULE CODE AND TITLE: CSACI301 ELECTRONIC CIRCUIT IMPLEMENTATION

Learning Outcome 1: Simulate electronic circuit.
Learning Outcome 2: Build electronic Circuit.
Learning Outcome 3: Troubleshoot electronic circuit.



Graphic Equalizer *
File
Edit
View
Help
Build
Run
Analyze
Components
Analog/Mixed
Drawing
Wire Draw
Text-Annot...
Basic Components
Resistor
Inductor
Capacitor
Switch
Ground
Potentiome...
Virtual Devices
DC-Source
Function-G...
Oscilloscope
TBS
Power-Supp...
AFG
AFG3000
2100
Digital-Mu...
Sources
Equations
R14
R16
R15
R7
R13
R9
OpAmp2
1.5916 V
Input
C2
C = 100 nF
R8
R = 15.9 KOhm
R5
R = 79 Ohms
C3
C = 100 nF
R10
R = 31.8 KOhms
OpAmp1
R11
R = 10 KOhms
R6
R = 10 KOhms
R20
56.086 mV
Output_1k
C1
C = 100 nF
R0
R = 63.7 KOhms
R1
R = 319 Ohms
C0
C = 100 nF
R2
R = 127 KOhms
OpAmp0
R3
R = 10 KOhm
R4
R = 10 KOhms
R21
48.571 mV
Output_250
R24

Indicative contents

1.1 Interpretation of Circuit diagram.
1.2 Description of Circuit simulation software
1.3 Installation of Circuit simulation software
1.4 Set up Workspace Environment
1.5 Selection of electronic Tools, components and equipment
1.6 Labelling of electronic circuit components
1.7 Interconnection of Electronic components
1.8 Exporting Circuit diagram

Key Competencies for Learning Outcome 1: Simulate Electronic Circuit.

Knowledge	Skills	Attitudes
• Description of electronic circuit diagram. • Description of electronic circuit simulation software. • Description of workplace environment • Identification of exporting options and simulation software settings	• Installing electronic simulation software • Arranging workplace environment • Designing electronic circuit diagram • Using electronic simulation software • Labelling electronic components • Interconnecting electronic components • Generating electronic circuit diagrams	• Having Precision • Being Attentive • Having self-confident • Having accountability • Respecting time • Being patient • Having self-motivation • Being organized

Duration: 30hrs

Learning outcome 1 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Describe properly electronic circuit interpreted according to the circuit functionality.
2. Select correctly Circuit simulation software based on their types and functions.
3. Install effectively Circuit simulation software in line with installation steps.
4. Customize successfully circuit simulation according to software functionalities.

5. Arrange appropriately working environment by using arrangement techniques
6. Interconnect appropriately electronic Components with respect to component terminals
7. Name correctly electronic Components following the given circuit Diagram
8. Generate appropriately electronic Circuit diagram according to the required file format

Resources

Equipment	Tools	Materials
• Computer • External storage devices	• Circuit Simulation software (NI Multisim, Proteus, Autodesk Eagle)	• Electricity • Internet bundles • Software license

Indicative content 1.1: Interpretation of Circuit Diagram

Duration: 4 hrs

Theoretical Activity 1.1.1: Description of electronic Circuits symbols and physical components

Tasks:

1: You are asked to answer the following questions:

   i. What is an electronic circuit?

   ii. What is an electronic circuit diagram?

   iii. What are types of electronic circuit?

   iv. Give at least 5 symbols used in circuit diagrams and explain what they represent

2: Provide the answers for the asked questions and write them on flipchart/papers.

3: Present the findings/answers to the whole class.

4: Ask questions where necessary and for more clarification, read the key readings 1.1.1.

Key readings 1.1.1: Description of electronic Circuits symbols and physical components

1. Definitions

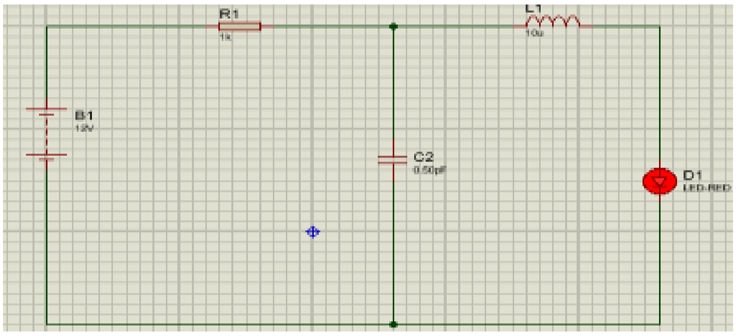
1.1 Electronic Circuit

An electronic circuit is the combination of different active and passive components such as resistors, capacitors, inductors, diodes, etc. which form an electrical network. In a closed-loop circuit, the electric current flows from the source (such as battery) in the conducting material (e.g. wires and cables) to the load (i.e. light bulb) and hence returns back to the source.

1.2 Circuit diagram

It is also known as an electrical diagram, elementary diagram, or electronic schematic, is a graphical representation that simplifies an electrical circuit.

Example of electronic circuit diagram



Electronic Circuit is circuit which consisting of more than one electronic components such as diodes, transistors, resistors, capacitors etc. where at least one of active components must be presented in the circuit which further differentiate it from the electrical circuit. This way, it is known as an electronic circuit instead of an electrical circuit.

2. Types of Electronic Circuit

Electronic circuits can be classified based on various criteria. Here are some common ways to categorize them:

2.1. Based on Current Flow

✓**Direct Current (DC) Circuits:**
Description: Circuits with a constant current that flows in a single direction.
Examples**:** Battery-powered devices, DC motors, and simple electronic devices.
✓**Alternating Current (AC) Circuits:**
Description: Circuits where the current periodically reverses direction and the voltage oscillates.
Examples: Household electrical systems, AC power supplies, and transformers.
✓**Pulsating Current Circuits:**
Description: Circuits with current that fluctuates or pulses but does not reverse direction like AC.
Examples: Rectifier circuits, switching power supplies.

2.2. Based on Functionality

✓**Analog Circuits:**
Description: Circuits that handle continuous signals and work with real-world phenomena.
Examples: Amplifiers, oscillators, and filters.
✓**Digital Circuits:**
Description: Circuits that process discrete signals and work with binary data (0s and 1s).
Examples**:** Microprocessors, memory chips, and logic gates.
✓**Mixed-Signal Circuits:**
Description: Circuits that handle both analog and digital signals.

Examples: Analog-to-digital converters (ADCs), digital-to-analog converters (DACs), and communication systems.

2.3. Based on Components

✓**Linear Circuits:**

Description: Circuits in which the output is directly proportional to the input.

Examples: Operational amplifiers (op-amps), voltage dividers.

✓**Nonlinear Circuits:**

Description: Circuits where the output is not directly proportional to the input.

Examples: Diode circuits, transistor amplifiers, and rectifiers.

2.4 Based on Complexity

✓**Simple Circuits:**

Description: Basic circuits with few components and straightforward functionality.

Examples: Series and parallel resistive circuits, basic RC filters.

✓**Complex Circuits:**

Description: Circuits involving multiple interconnected components and sophisticated functionality.

Examples: Integrated circuits (ICs), microcontroller-based systems, and complex communication systems.

2.5. Based on Configuration

✓**Series Circuits:**

Description: Circuits where components are connected end-to-end so that the current flows through each component sequentially.

Examples: Simple battery-powered circuits with resistors in series.

✓**Parallel Circuits:**

Description: Circuits where components are connected across common points, so the current can flow through multiple paths.

Examples: Household electrical wiring, parallel resistor networks.

✓**Series-Parallel Circuits:**

Description: Circuits that combine both series and parallel configurations.

Examples: Complex resistor networks, multi-stage filters.

2.6. Based on Power Handling

✓**Low-Power Circuits:**

Description: Circuits designed to operate with low electrical power.

Examples: Battery-operated devices, low-power sensors.

✓**High-Power Circuits:**

Description: Circuits designed to handle and dissipate significant amounts of power.

Examples: Power amplifiers, electric motor controllers.

3. Circuit Symbols and Physical Components

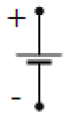
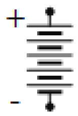
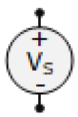
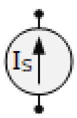
3.1 Basic Schematic Symbols

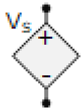
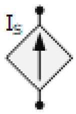
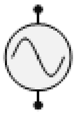
Electrical & electronic symbols and images are used by engineers in circuit diagrams and schematics to show how circuit components are connected together

Circuit layouts and schematic diagrams are a simple and effective way of showing pictorially the electrical connections, components and operation of a particular electrical circuit or system. Basic electrical and electronic graphical symbols called **Schematic Symbols** are commonly used within circuit diagrams, schematics and computer aided drawing packages to identify the position of individual components and elements within a circuit.

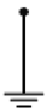
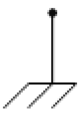
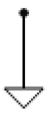
The IEC (International Electrotechnical Commission) have one set of symbols, while the IEEE (Institute of Electrical and Electronics Engineers) have an alternative set

3.1.1 Power Supply Schematic Symbols

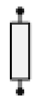
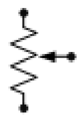
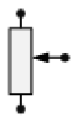
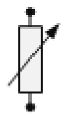
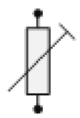
Schematic Symbol	Symbol Identification	Description of Symbol
	Single Cell	A single DC battery cell of 0.5V
	DC Battery Supply	A collection of single cells forming a DC battery supply
	DC Voltage Source	A constant DC voltage supply of a fixed value
	DC Current Source	A constant DC current supply of a fixed value

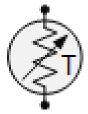
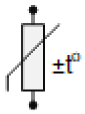
	Controlled Voltage Source	A dependent voltage source controlled by an external voltage or current
	Controlled Current Source	A dependent current source controlled by an external voltage or current
	AC Voltage Source	A sinusoidal voltage source or generator

3.1.2 Electrical Grounding Schematic Symbols

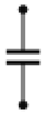
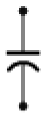
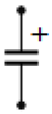
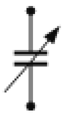
Schematic Symbol	Symbol Identification	Description of Symbol
	Earth Ground	Earth ground referencing a common zero potential point
	Chassis Ground	Chassis ground connected to the power supplies earthing pin
	Digital Ground	A common digital logic circuit ground line

3.1.3 Resistor Schematic Symbols

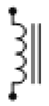
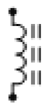
Schematic Symbol	Symbol Identification	Description of Symbol
	Fixed Resistor (IEEE Design)	A fixed value resistor whose resistive value is indicated next to its schematic symbol
	Fixed Resistor (IEC Design)	
	Potentiometer (IEEE Design)	Three terminal variable resistance whose resistive value is adjustable from zero to its maximum value
	Potentiometer (IEC Design)	
	Rheostat (IEEE Design)	Two terminal fully adjustable rheostat whose resistive value varies from zero to a maximum value
	Rheostat (IEC Design)	
	Trimmer Resistor	Small variable resistors for mounting onto PCB's

	Thermistor (IEEE Design)	Thermal resistor whose resistive value changes with changes in surrounding temperature
	Thermistor (IEC Design)	

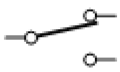
3.1.4 Capacitor Schematic Symbols

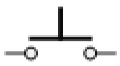
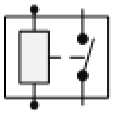
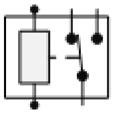
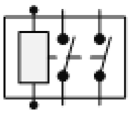
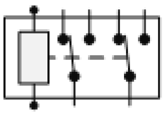
Schematic Symbol	Symbol Identification	Description of Symbol
	Fixed Value Capacitor	A fixed value parallel plate non-polarised AC capacitor whose capacitive value is indicated next to its schematic symbol
	Fixed Value Capacitor	
	Polarized Capacitor	A fixed value polarised DC capacitor usually an electrolytic capacitor which must be connected to the supply as indicated
	Variable Capacitor	An adjustable capacitor whose capacitance value can be varied by means of adjustable plates

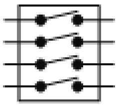
3.1.5 Inductor and Coil Schematic Symbols

Schematic Symbol	Symbol Identification	Description of Symbol
	Open Inductor	An open inductor, coil or solenoid that generates a magnetic field around itself when energised
	Iron Core Inductor	An inductor formed by winding the coil around a solid laminated iron core indicated by solid lines
	Ferrite Core Inductor	An inductor formed by winding the coil around a non-solid ferrite core indicated by dashed lines

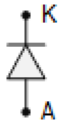
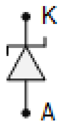
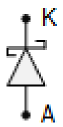
3.1.6 Switch and Contact Symbols

Schematic Symbol	Symbol Identification	Description of Symbol
	SPST Toggle Switch	Single-pole single-throw toggle switch used for making (ON) or breaking (OFF) a circuits current
	SPDT Changeover Switch	Single-pole double-throw changeover switch used for changing the direction

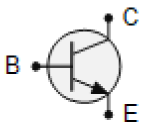
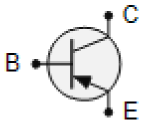
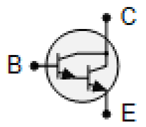
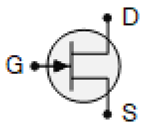
		of current flow from one terminal to another
	Pushbutton Switch (N.O)	Normally open contacts pushbutton switch – push to close, release to open
	Pushbutton Switch (N.C)	Normally closed contacts pushbutton switch – push to open, release to close
	SPST Relay Contacts	Electromechanical relay with internal single-pole single-throw toggle contacts
	SPDT Relay Contacts	Electromechanical relay with internal single-pole double-throw changeover contacts
	DPST Relay Contacts	Electromechanical relay with internal double-pole single-throw toggle contacts
	DPDT Relay Contacts	Electromechanical relay with internal double-pole double-throw changeover contacts

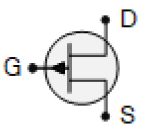
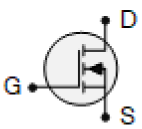
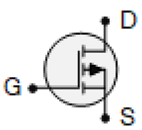
	DIP Switch Assembly	PCB mounted DIP switch with 1-to-10 toggle switches either single-pole, double-pole, rotary or with a common terminal

3.1.7 Semiconductor Diode Symbols

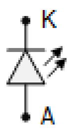
Schematic Symbol	Symbol Identification	Description of Symbol
	Semiconductor Diode	Semiconductor pn-junction diode used for rectification and high current applications
	Zener Diode	Zener diode used in its reverse voltage breakdown region for voltage limiting and regulation applications
	Schottky Diode	Schottky diode consisting of an n-type semiconductor and metal electrode junction for low voltage applications

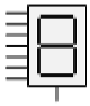
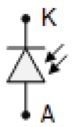
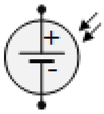
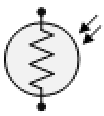
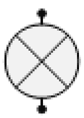
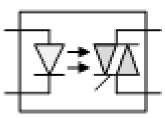
3.1.8 Transistor Symbols

Schematic Symbol	Symbol Identification	Description of Symbol
	NPN Bipolar Transistor	Characterised as being a lightly doped p-type base region between two n-type emitter and collector regions with the arrow indicating direction of conventional current flow out.
	PNP Bipolar Transistor	Characterised as being a lightly doped n-type base region between two p-type emitter and collector regions. Arrow indicates direction of conventional current flow in.
	Darlington Pair Transistor	Two bipolar transistor npn or pnp connected in a series common collector configuration to increase current gain
	N-JFET Transistor	N-channel junction field effect transistor having an n-type semiconductive channel between source and drain with the arrow indicating direction of conventional current flow

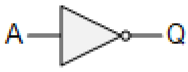
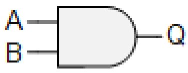
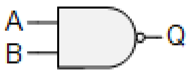
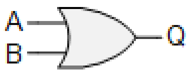
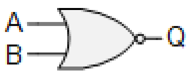
	P-JFET Transistor	P-channel junction field effect transistor having a p-type semiconductive channel between source and drain with the arrow indicating direction of conventional current flow
	N-MOSFET Transistor	N-channel metal-oxide semiconductor field effect transistor with an insulated gate terminal which can be operated in depletion or enhancement mode
	P-MOSFET Transistor	P-channel metal-oxide semiconductor field effect transistor with an insulated gate terminal which can be operated in depletion or enhancement mode

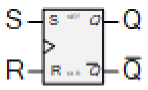
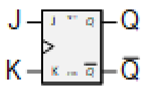
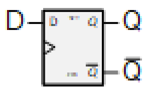
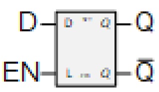
3.1.9 Photo device Schematic Symbols

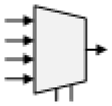
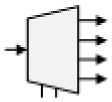
Schematic Symbol	Symbol Identification	Description of Symbol
	Light Emitting Diode (LED)	A semiconductor diode which emits coloured light from its junction when forward biased

	7-segment Display	A 7-segment display used common cathode (CC) or common anode (CA) for displaying single numbers and letters
	Photodiode	A semiconductor device which allows current to flow when exposed to incident light energy
	Solar Cell	P–N junction photovoltaic cell transducer which converts light intensity directly into electrical energy
	Photo resistor	Light dependent resistor (LDR) which changes its resistive value with changes in light intensity
	Indicator Lamp or Light Bulb	A filament lamp, indicator or other which emits visible light when a current flows through it
	Opto-isolator or Optocoupler	An Opto-isolator or Optocoupler which uses photo-sensitive devices to isolate its input and output connections

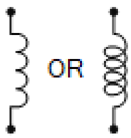
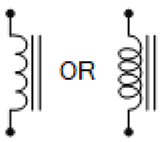
3.1.10. Digital Logic Symbols

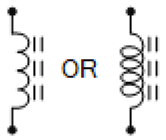
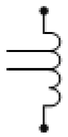
Schematic Symbol	Symbol Identification	Description of Symbol
	NOT Gate	Logic gate with only one input and one output and outputs a logic 1 (HIGH) when input is 0 (LOW) and outputs a 0 when input is 1 (Inverter)
	AND Gate	Logic gate with two or more inputs which outputs a logic 1 (HIGH) when ALL of its inputs are at logic 1 (HIGH)
	NAND Gate	Logic gate with two or more inputs that outputs a logic 0 (LOW) when ALL of its inputs are HIGH at logic 1 (Equivalent to NOT + AND)
	OR Gate	Logic gate with two or more inputs which outputs a logic 1 (HIGH) when ANY (or both) of its inputs are at logic 1 (HIGH)
	NOR Gate	Logic gate with two or more inputs that outputs a logic 0 (LOW) when ANY (or both) of its inputs are HIGH at logic 1 (Equivalent to NOT + OR)

	XOR Gate	Exclusive-OR gate with two inputs that outputs a logic 1 (HIGH) whenever its two inputs are DIFFERENT
	XNOR Gate	Exclusive-NOR gate with two inputs that outputs a logic 1 (HIGH) whenever its two inputs are the SAME (NOT + XOR)
	SR Flip-Flop	Set-Reset Flip-flop is a bistable device used to store one bit of data on its two complementary outputs
	JK Flip-Flop	JK (Jack Kilby) Flip-flop has the letter J for Set and the letter K for Reset (Clear) with internal feedback
	D-type Flip-Flop	D (Delay or Data) Flip-flop is a single input flip-flop which toggles between its two complementary outputs
	Data Latch	Data latch stores one data bit on its single input when EN enable pin is LOW and outputs the data bit transparently when the EN enable pin is HIGH

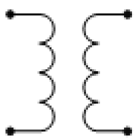
	4-to-1 Multiplexer	A Multiplexer passes the data on one of its inputs pins to a single output line
	1-to-4 DE multiplexer	A DE multiplexer passes the data on its single input pin to one of several output lines

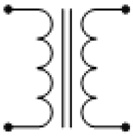
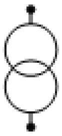
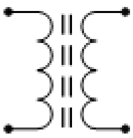
3.1.11. Schematic Symbols for Inductors

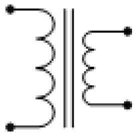
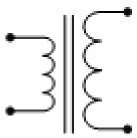
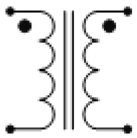
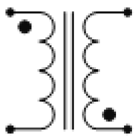
Schematic Symbol	Symbol Identification	Description of Symbol
	Air-core Inductor	A fixed value air-core inductor, coil, solenoid or choke which uses either a self-supporting form or a solid or hollow ceramic, plastic, or some other form of non-magnetic material as its inner core for high frequency applications
	Iron-core Inductor	A fixed value solid iron-core inductor formed by winding the coil around a solid laminated iron core, indicated by the symbols two solid lines, to concentrate the magnetic field generated around itself when energised

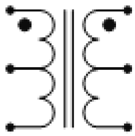
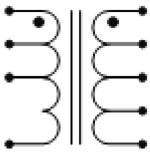
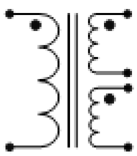
	Ferrite Core Inductor	A fixed value inductor formed by winding the coil around a non-solid compressed powdered ferrite core or bead indicated by the symbols two dashed lines
	Tapped Inductor	An inductor coil with either one or more fixed value connections called, taps, along its length for impedance matching and tank circuits
	Adjustable Inductor	An adjustable or continuously adjustable inductor whose self-inductance value can be varied from some minimum value to a maximum value when adjusted

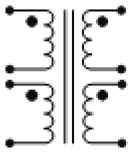
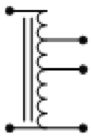
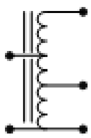
3.1.12 Schematic Transformer Symbols

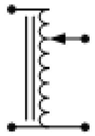
Schematic Symbol	Symbol Identification	Description of Symbol
	Air-core Transformer	Single-phase air-core voltage transformer with two inductive coils wrapped closely together around a solid or hollow

		plastic non-magnetic core for radio frequency applications
	Iron-core Transformer	Single-phase iron-core voltage transformer (VT) formed by winding the two coils around a solid laminated iron core, indicated by the symbols two solid lines, for the transfer of electrical energy from one winding to the other changing an AC voltage from high to low or low to high
	Power Transformer	Single-phase power transformer (PT) shown as two interconnecting circles for the transmission and distribution of electrical power from high to low or low to high
	Ferrite-core Transformer	Single-phase transformer formed by winding the two coils around a non-solid compressed ferrite core to decrease eddy current losses, hum and increase the magnetising flux. Used mainly in toroidal transformers

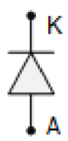
	Step-down Transformer	Single-phase step-down isolation transformer which converts a higher primary winding voltage into a lower secondary winding voltage by an amount determined by the turns ratios of the transformer
	Step-up Transformer	Single-phase step-up isolation transformer which converts a lower primary winding voltage into a higher secondary winding voltage by an amount determined by the turns ratios of the transformer
	0^o Phase Shift	Inline dot orientation used to indicate the 0^o phase-shift between the primary and secondary windings used to correctly parallel connect transformers together
	180^o Phase Shift	Diagonal and opposite dot orientation used to indicate the 180^o phase-shift between the primary and secondary windings

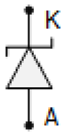
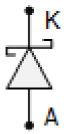
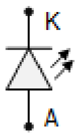
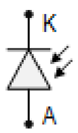
		resulting in voltage and current inversion
	Center-tapped Transformer	Single-phase center-tapped voltage transformer with either primary, secondary or both sides divided into two windings allowing for multiple voltage points. Primary center tap allows for dual supplies, while secondary center tap is useful in rectifier circuits
	Multi-tapped Transformer	Single-phase Multi-tapped voltage transformer either primary, secondary or both allowing for multiple voltage connection and take-off points
	Multi-load Transformer	Single-phase voltage transformer with one or more magnetically coupled secondary windings to supply individual loads, or the secondary windings may be connected in parallel for a greater current, or in series for a higher voltage

	Dual-winding Transformer	Single-phase voltage transformer consisting of two transformers on the same core, with the primary and secondary windings of each transformer wound on the same magnetic core. For use in both low and high voltage supplies and PSU applications
	Iron-core Autotransformer	Single-phase step-down autotransformer with one single coil for both the primary and the secondary windings wrapped around a magnetic iron-core and one or more fixed tapping points giving a secondary voltage equal to or less than the primary voltage
	Iron-core Autotransformer	Single-phase step-up autotransformer with one single coil for both the primary and the secondary windings wrapped around a magnetic iron-core and one or more fixed tapping points giving a secondary voltage equal to or more than the primary voltage

	Variac	Single-phase variable autotransformer called a variac with one single tapping point which can be adjusted to produce a variable secondary voltage. Does not provide isolation
	Current Transformer	Step-down current transformers (CT) wound, toroidal or bar type which provides electrical isolation between the high-current carrying conductor and metering device

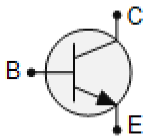
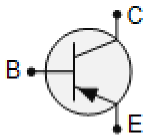
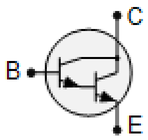
3.1.13 Semiconductor Diode Symbols

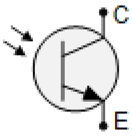
Schematic Symbol	Symbol Identification	Description of Symbol
	Semiconductor Diode	Semiconductor pn-junction diode which passes current when forward-biased, and blocks current flow when reverse-biased. Commonly used in small-signal, rectification or high current applications

	Zener Diode	Zener diode used in its reverse voltage breakdown region for voltage limiting, transient suppression and regulation applications. Available in a range of reverse breakdown voltage values
	Schottky Diode	Schottky diode consisting of an n-type semiconductor and metal electrode junction producing a very low forward voltage drop and power dissipation and faster switching speed compared to a pn-junction diode
	Light Emitting Diode (LED)	A semiconductor diode which emits a range of visible and non-visible coloured light from its pn-junction depending on the materials and doping used when forward biased
	Photodiode	A semiconductor photosensor= which allows current to flow through itself in the reverse direction when

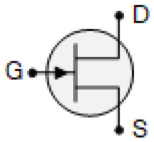
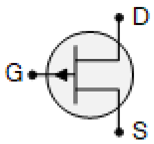
		exposed to incident light energy

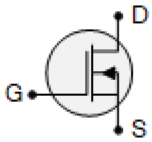
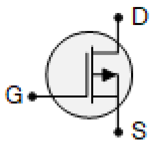
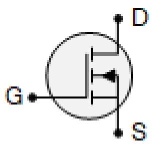
3.1.14 Schematic Semiconductor Symbols for Bipolar Junction Transistors

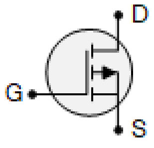
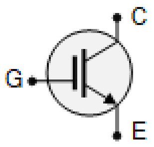
Schematic Symbol	Symbol Identification	Description of Symbol
	NPN Bipolar Transistor	Characterised as being a lightly doped p-type base region between two n-type emitter and collector regions with the arrow indicating direction of conventional current flow out
	PNP Bipolar Transistor	Characterised as being a lightly doped n-type base region between two p-type emitter and collector regions. Arrow indicates direction of conventional current flow in
	Darlington Pair Transistor	Two bipolar transistor npn or pnp connected in a series common collector configuration to increase overall current gain. Available in PNP and Sziklai pair configuration

	Phototransistor	NPN Phototransistor sealed in a protective case with glass lens or window for detecting external visible and near infrared light sources. Some models have a base (B) lead available to enable biasing and sensitivity control

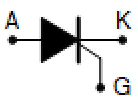
3.1.15 Schematic Symbols for Field Effect Transistors

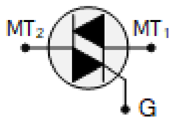
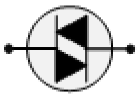
Schematic Symbol	Symbol Identification	Description of Symbol
	N-JFET Transistor	N-channel junction field effect transistor having an n-type semiconductive channel between the Source (S) and Drain (D) terminals with the Gate (G) arrow pointing inwards to indicate direction of conventional current flow
	P-JFET Transistor	P-channel junction field effect transistor having a p-type semiconductive channel between Source (S) and Drain (D) terminals with the Gate (G) arrow pointing outwards to indicate

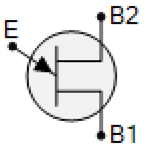
		direction of conventional current flow
	N-channel D-MOSFET Transistor	Depletion N-channel Metal-Oxide Semiconductor FET (nMOSFET) has a Gate terminal insulated from the main conductive channel and which is *normally-on* and conducting when V_G = 0 volts
	P-channel D-MOSFET Transistor	Depletion P-channel Metal-Oxide Semiconductor FET (pMOSFET) has a Gate terminal insulated from the main conductive channel and which is *normally-on* and conducting when V_G = 0 volts
	N-channel E-MOSFET Transistor	Enhancement N-channel Metal-Oxide Semiconductor FET (nMOSFET) has a Gate terminal insulated from the main channel and which is *normally-off* and closed when V_G = 0 volts

	P-channel E-MOSFET Transistor	Enhancement P-channel Metal-Oxide Semiconductor FET (pMOSFET) has a Gate terminal insulated from the main channel and which is *normally-off* and closed when V_G = 0 volts
	IGBT Transistor	Insulated Gate Bipolar Transistor (IGBT) is a cross between a BJT and IGFET offering high input MOS characteristics and large bipolar output current-carrying capability and low saturation voltage

3.1.16 Schematic Semiconductor Symbols for Power Devices

Schematic Symbol	Symbol Identification	Description of Symbol
	Silicon Controlled Rectifier	A Silicon Controlled Rectifier (SCR) or Thyristor is a 3-terminal, four-layered PNPN semiconductor unidirectional device with its main terminals labelled Anode (A), Cathode (K) and Gate (G). Once triggered ON it remains conducting as long as current flows through it

		and can operate at higher voltages and currents
	Triac	The TRIAC named from *Triode for Alternating Current* is a 3-terminal bidirectional device, which can conduct current in both directions. Its main terminals are labelled MT2, MT1 and Gate (G) and can be triggering into conduction in either direction of the sinusoidal waveform
	Diac	The DIAC named from *Diode for Alternating Current* is a 2-terminal bidirectional semiconductor device similar to a PNP transistor without a base terminal characteristic of two diodes back-to-back. Used together with a Triac to conduct current in both directions in AC phase-control, dimming, speed-control and power-control applications

	Unijunction Transistor	The Unijunction Transistor (UJT) is a semiconductor 3-terminal, single pn-junction switching device with its main terminals labelled Base-1 (B1), Base-2 (B2) and Emitter (E). Programmable UJT's use external resistors to set their switching parameters and are common in relaxation oscillators

Theoretical Activity 1.1.2: Description of line presentation, junction and nodes

Task:

1: You are asked to answer the following questions:

i. Define the following terms:

a. Line presentation

b. Junction

c. Nodes

ii. List the main line presentations used in designing electronic circuit.

iii. Differentiate junctions and nodes that can form electronic circuit.

2: Provide the answers for the asked questions and write them on flipchart/papers.

3: Present the findings/answers to the whole class.

4: Ask questions where necessary for more clarification, read the key readings 1.1.2.

Key readings 1.1.2:

Description of line presentation, junction and nodes

1. Lines representation

Refers to the way electrical connections and signal pathways are visually represented in a circuit diagram or schematic.

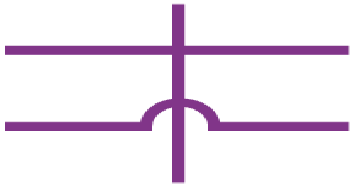
- ✓ **Electrical Wire**

A wire is a single, usually cylindrical, flexible strand or rod of metal through which electric current flows. It is usually made of good conducting metals such as copper.

Connecting wires provide a medium to an electrical current so that they can travel from one point on a circuit to another.

- ✓ **Disconnected Wire**

In diagrams, we come across situations where we have wires crossing through other wires even though they are not connected to each other. Hence, it is preferred to have a hump as shown to depict the crossing of one wire over another wire.



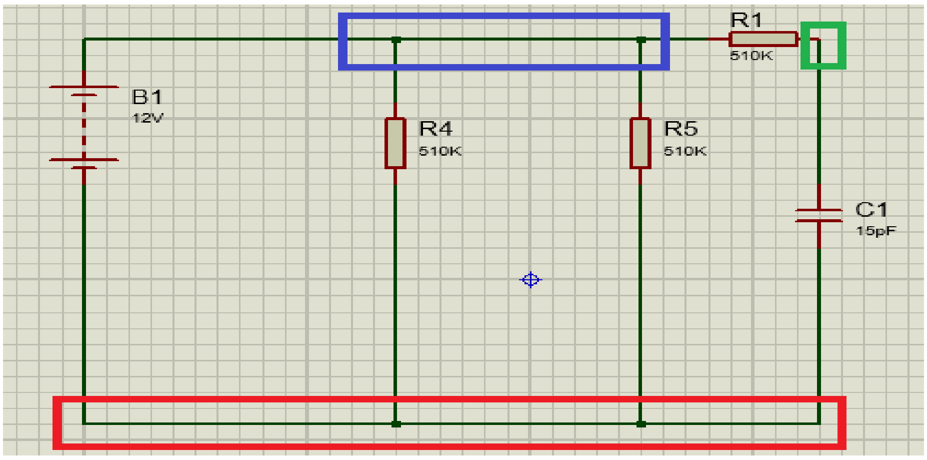
- ✓ **Earth Ground**

The reference point in an electrical circuit from which voltages are measured, a common return path for electric current, or a direct physical connection to the earth.

2. Junction and nodes

2.1 Junction

Any point in a circuit where current separates is generally referred to as a junction. A junction is also known as a node that connects three or more circuit elements.



Elements are black, nodes are colored, and junctions are black dots between elements or wires.

2.2 Node

A point in a circuit where two or more circuit elements meet is known as an **electrical node**. A resistor, capacitor, transistor, and other elements are examples of elements. Each element has terminals; the element connects to the circuit through terminals.

A node is the point at which the terminals of two elements meet.

Three nodes connect the items in the circuit above:

1. Resistors R4, R5, and R1 and the terminals of the DC voltage source V1 form first node (blue). The terminals are in black because they aren't technically part of the node.
2. Second node (green) is between the terminals of resistor R1 and capacitor C1.
3. Third node (red) is between the terminals of the DC voltage source V1, the resistors R4 and R5, and the capacitor C1.

2.3 Difference between node and junction

In electronic circuits, **nodes** and **junctions** both refer to points where components connect, but they have distinct meanings:

A **node** is a point in a circuit where two or more components' terminals are connected. Nodes represent electrical connections at the same potential and can include multiple junctions within a circuit while a **junction** specifically refers to the point where two or more conductive paths physically meet, such as the intersection of wires or where components like transistors have their terminals connected.

Theoretical Activity 1.1.3: Description of types of circuit connections

Task:

1: You are asked to answer the following questions:

i. What is circuit connection?
ii. List the main types of circuit connections.
iii. Differentiate all types of circuit connections.

2: Provide the answers for the asked questions and write them on flipchart/papers.
3: Present the findings/answers to the whole class.
4: For more clarification, read the key readings 1.1.3.

Key reading 1.1.3:

Description of types of circuit connections

1. Definition of Circuit Connection

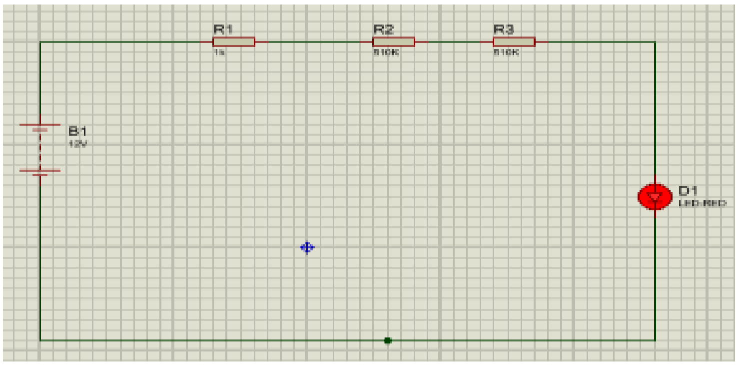
Refers to the physical and electrical pathways that link various components within the circuit. Those connections allow electrical current to flow between components.

2. Types of circuit connections

Circuit Connection types circuits can be classified as series or parallel circuits based on how these elements are arranged.

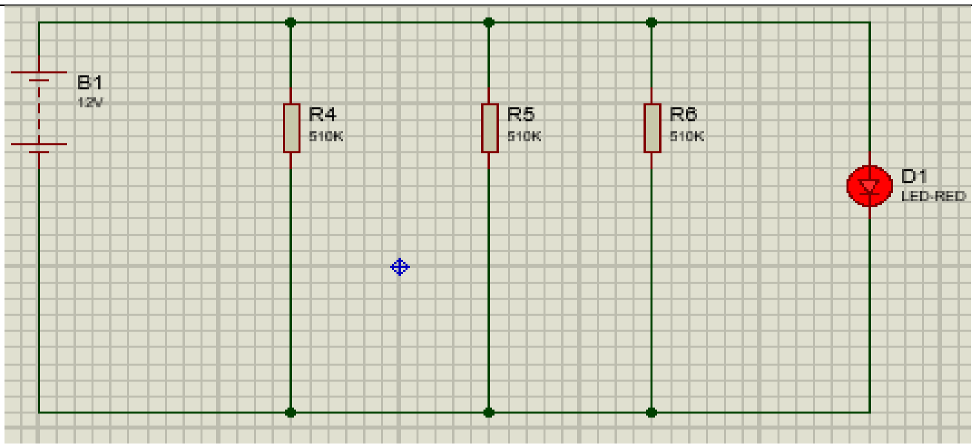
2.1. Series Circuit

In a series circuit, circuit elements are arranged in one single path so that the same current must flow through them all. In this circuits, all the electrical elements (Voltage or Current sources, inductors, capacitors, resistors etc.) are connected in series i.e. There is only one path for traveling electricity e.g. these are single branch circuits.



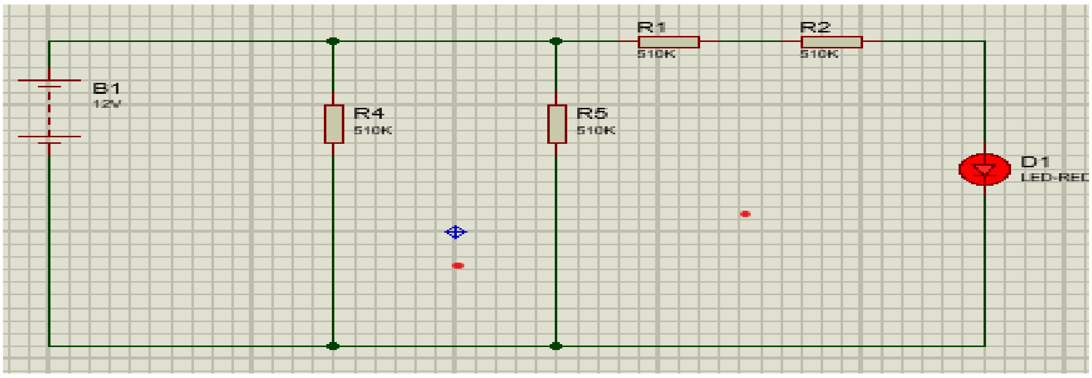
2.2. Parallel Circuit

In this circuits, all the electrical elements (Voltage and Current sources, inductors, capacitors, resistors etc) are connected in parallel i.e. There are many paths for traveling electricity and the minimum branches in this circuit are two.



2.3. Series-Parallel Circuit

If circuit elements are series connected in some parts and parallel in others that would be a series-parallel circuit. In other words, this is a combination of series, parallel and series-parallel circuits.



Practical Activity 1.1.4: Drawing electronic circuit diagram

Task:

1: You are requested to in school workshop to draw a 5vdc power supply on your paper/flip chart.

2: Read the key readings 1.1.4 about the drawing the steps of 5vdc power supply on your paper/ flip chart.
3: By following the steps from key reading, perform the given task
4: Present the work to the whole class.
5: In addition, ask questions where necessary and perform the task in the application of leaning 1.1

Key readings 1.1.4:

Drawing electronic circuit diagram

Drawing an electronic circuit diagram involves representing electrical components and their connections using standard symbols. Whether you are using software or drawing by hand, here is a step-by-step guide to help you create a clear and accurate electronic circuit diagram:

The steps to draw a simple 5V DC power supply circuit on paper or a flip chart as an example of an electronic circuit diagram:

Materials Needed

- Paper or flip chart
- Ruler (optional)
- Pencil or pen

Steps to Draw a 5V DC Power Supply

✓ **Identify the Purpose of the Circuit**:
Determine what the circuit is intended to do (e.g., power supply, amplifier, sensor circuit).

✓ **Gather Required Components:**
List all the components you will need for the circuit, such as resistors, capacitors, diodes, transistors, power sources, etc.

✓ **Choose the Right Symbols**:
Familiarize yourself with standard electronic symbols for each component. For example:
Resistor**:** A zigzag line
Capacitor**:** Two parallel lines
LED**:** A diode symbol with arrows indicating light emission.

✓ **Draw the Power Supply**:

Start with the power source, drawing a battery symbol or DC voltage source at one end of the diagram. Label it with its voltage.

✓ **Add Ground Connection**:
Draw a ground symbol to indicate the reference point of the circuit, usually at the bottom. This is important for circuit stability.

✓ **Place Components in the Diagram**:
Sketch the symbols for each component in their respective positions according to the circuit design. Ensure they are spaced adequately for connecting wires.

✓ **Connect the Components with Wires**:
Use straight lines to connect the components. Each line represents a wire. Make sure the connections are clear and avoid crossing lines whenever possible.

✓ **Label Each Component**:
Assign a unique identifier to each component (e.g., R1 for the first resistor, C1 for the first capacitor) and label them clearly.

✓ **Indicate Component Values**:
Write down the values next to each component (e.g., “1kΩ” for a resistor, “10µF” for a capacitor) for reference.

✓ **Show Current Direction (optional)**:
You may add arrows along the wires to indicate the direction of current flow, usually from positive to negative.

Points to Remember

- **An electronic circuit** is the combination of different active and passive components such as resistors, capacitors, inductors, diodes, transistors etc. which form an electrical network. In a closed-loop circuit, the electric current flows from the source (such as battery) in the conducting material (e.g. wires and cables) to the load (i.e. light bulb) and hence returns back to the source.
- **Circuit diagram**

It is also known as an electrical diagram, elementary diagram, or electronic schematic, is that simplifies an electronic circuit

- **Physical electronic components:** are the tangible, real-world elements used to construct electronic circuits. For examples: resistors, capacitors, diodes, relays, transistor, etc.…
- **Circuit symbols and physical components which are commonly used**
  - ✓ Power Supply Schematic Symbols.
  - ✓ Electrical Grounding Schematic Symbols
  - ✓ Resistor Schematic Symbols
  - ✓ Capacitor Schematic Symbols
  - ✓ Inductor and Coil Schematic Symbols
  - ✓ Switch and Contact Symbols
  - ✓ Semiconductor Diode Symbols
  - ✓ Schematic Semiconductor Symbols for Power Devices
  - ✓ Schematic Symbols for Field Effect Transistors

- There are many **types of electronic circuits** and they are classified based on:
  - ✓ Based on Current Flow
  - ✓ Based on Functionality
  - ✓ Based on Components
  - ✓ Based on Configuration
  - ✓ Based on Power Handling
  - ✓ Based on Complexity
- **Lines representation:** Refers to the way electrical connections and signal pathways are visually represented in a circuit diagram or schematic.
- **Electrical Wire:** A wire is a single, usually cylindrical, flexible strand or rod of metal through which electric current flows.
- **Connected Wire** includes:
  - ✓ Disconnected Wire and
  - ✓ Earth Ground.
- **Difference between node and junction**

In electronic circuits, **nodes** and **junctions** both refer to points where components connect, but they have distinct meanings:

A **node** is a point in a circuit where two or more components' terminals are connected. Nodes represent electrical connections at the same potential and can include multiple junctions within a circuit while a **junction** specifically refers to the point where two or more conductive paths physically meet, such as the intersection of wires or where components like transistors have their terminals connected.

- **Circuit Connection:**

Refers to the physical and electrical pathways that link various components within the circuit. Those connection allows electrical current to flow between components.

- **Circuit Connection types** can be classified as **series** or **parallel** circuits based on how these elements are arranged.
- **Difference between the types of circuit connections**.
- Series Circuit: In a series circuit, circuit elements are arranged in one single path so that the same current must flow through them all.
- Parallel Circuit: In this circuits, all the electrical elements (Voltage and Current sources, conductors, capacitors, resistors etc.) are connected in parallel i.e. There are many paths for traveling electricity and the minimum branches in this circuit are two.
- When drawing electronic circuit diagram you have to follow the following steps: gather information, select tools, learn standard symbols, start with power source, add components, draw connections, label components and finalize the diagram.

Application of learning 1.1.

KIGALI Electronic Innovations Group is a company designed to implement electronic projects and you are hired as a skilled technician to Draw circuit diagram that present 5VDC power supply on the physical sheet. before it is made and implemented ;remember to set the names of the components and other element so that your drawing is understandable to the people who will implement it.

Indicative content 1.2: Description of Circuit Simulation Software

Duration: 4 hrs

Theoretical Activity 1.2.1: Description of circuit simulation software, their versions and their features

Task:

1: You are asked to answer the following questions:

i. What is Simulation software?
ii. Describe the Versions and features of Simulation Software.
iii. What are the types of versions and features of simulation software?
iv. List the examples of Electronics simulation software.

2: Provide the answers for the asked questions and write them on flipchart/papers.

3: Present the findings/answers to the whole class.

4: Ask questions where necessary and for more clarification, read the key readings 1.2.1.

Key readings 1.2.1: Description of circuit Simulation software, their versions and their features

1. Definitions

Electronic circuit simulation software

Refers to crucial for designing, analysing, and testing electronic circuits before physical implementation. Here's a detailed overview of some of the most popular electronic circuit simulation tools, including their features and typical use cases:

Examples of Simulation software

- Multism
- Proteus
- Altium Designer
- Ki Cad
- Proteus
- Autodesk Eagle
- Altium Designer

2. Version and feature of simulation software

Versions refer to different editions or releases of the software, each offering varying features, capabilities, and levels of support, while
The feature of simulation software is poised to be influenced by several emerging trends and technological advancements.

2.1. Versions of simulation software

✓ **Standard Versions**
Purpose**:** These are the most commonly used versions, intended for general use by engineers, hobbyists, or students.
Examples: Proteus Professional, Multisim Standard.
Features**:** Core simulation and design tools, basic libraries, standard support.

✓ **Professional Versions**

Purpose**:** Designed for advanced users and professionals who need additional features, enhanced performance, and extended support.
Examples**:** Proteus Professional, Multisim Power Pro.
Features**:** Advanced simulation capabilities, extensive component libraries, integration with other tools.

✓ **Educational Versions**
Purpose**:** Tailored for academic institutions and students, often with restrictions on commercial use.
Examples**:** Multisim Student Edition, Proteus Educational Edition.
Features**:** Core simulation and design features, sometimes limited library access, educational pricing.

✓ **Enterprise Versions**
Purpose: For large organizations requiring enterprise-level features, extensive support, and customization.
Examples**:** Proteus Enterprise, Multisim Professional with Ultiboard.
Features**:** Full feature set, additional support, advanced integration capabilities.

✓ **Online or Cloud Versions**
Purpose**:** Accessible through web browsers, often offering basic functionality with cloud-based features.
Examples**:** Multisim Live.
Features**:** Basic simulation, cloud storage, collaborative features, limited to web-based access

2.2 Features of simulation software

- ✓ **Schematic Capture**

Purpose: Creating and editing circuit diagrams.

Features: Drag-and-drop interface, hierarchical design, component libraries, net list generation.

- ✓ **Circuit Simulation**

Purpose: Testing and analysing circuit behaviour.

Features: SPICE-based simulation, real-time analysis, transient analysis, frequency response.

- ✓ **PCB Design**

Purpose: Designing and laying out printed circuit boards.

Features: Auto-routing, manual routing, design rule checks, 3D visualization, component placement.

- ✓ **Microcontroller and Embedded Systems Simulation**

Purpose: Simulating microcontrollers and embedded systems.

Features: Microcontroller models, firmware simulation, debugging tools, integrated code editor

- ✓ **Virtual Instruments**

Purpose: Simulating measurement and analysis tools.

Features: Virtual oscilloscopes, logic analysers, multimeters, signal generators.

- ✓ **Integration with Other Tools**

Purpose: Enhancing the design and simulation workflow.

Features: Integration with CAD software, external hardware interfaces, data import/export.

- ✓ **Analysis and Reporting**

Purpose: Providing detailed analysis and documentation.

Features: Simulation result graphs, data logging, report generation, statistical analysis.

- ✓ **Educational and Training Tools**

Purpose: Supporting learning and teaching.

Features: Interactive tutorials, educational resources, simplified interface, guided exercises.

- ✓ **Cloud and Collaboration Tools**

Purpose: Facilitating remote access and teamwork.

Features: Cloud-based storage, collaborative design tools, sharing and commenting features.

Theoretical Activity 1.2.2: Description of technical specifications for simulation software.

Task:

1: You are asked to answer the following questions:

i. Describe the technical specifications for simulation software.

ii. List the minimum system requirements for running this simulation software.

2: Provide the answers for the asked questions and write them on flipchart/papers.

3: Present the findings/answers to the whole class.

4: For more clarification, read the key readings 1.2.2.

5: In addition, ask questions where necessary.

Key readings 1.2.2:

Description of technical specifications for simulation software.

The technical specifications for simulation software can vary widely depending on the type of simulation it performs, the complexity of the models, and the intended use cases. Below, there is a general overview of technical specifications typically associated with simulation software.

1. System Requirements

- ✓ **Operating System**: Compatibility with major operating systems such as Windows (e.g., Windows 10/11), macOS (e.g., macOS Big Sur, Monterey), and Linux distributions (e.g., Ubuntu, CentOS).
- ✓ **Processor**: Minimum and recommended CPU specifications (e.g., Intel i5/i7/i9, AMD Ryzen 5/7/9).
- ✓ **Memory (RAM)**: Minimum and recommended amounts (e.g., 8 GB minimum, 16-32 GB recommended for complex simulations).
- ✓ **Graphics Card**: Minimum and recommended GPU requirements (e.g., NVIDIA GTX 1060, RTX 2060 or higher for 3D visualization).

- ✓ **Storage**: Disk space required for installation and operation (e.g., 10 GB minimum, 50 GB or more for large datasets). SSD is recommended for faster performance.
- ✓ **Network**: Internet connection requirements for cloud-based simulations or online features.

2. Performance

- ✓ **Processing Speed**: Benchmarks for how quickly the software can process and solve simulations (often specified in terms of time per simulation or iterations per second).
- ✓ **Parallel Processing**: Support for multi-threading or multi-core CPUs, and GPU acceleration for faster computation.
- ✓ **Scalability**: Ability to handle simulations of varying sizes, from small-scale to large-scale models.

3. Features

- ✓ **Modelling Capabilities**: Types of simulations supported (e.g., finite element analysis (FEA), computational fluid dynamics (CFD), discrete event simulation (DES)).
- ✓ **Solver Types**: Availability of different solvers and algorithms (e.g., direct solvers, iterative solvers, Monte Carlo methods).
- ✓ **Customization**: Ability to extend or modify the software with scripting languages (e.g., Python, MATLAB) or plugins.

4. User Interface

- ✓ **Interface Design**: User-friendly interface with support for drag-and-drop functionality, intuitive navigation, and custom views.
- ✓ **Visualization**: Tools for visualizing results (e.g., 2D/3D graphs, contour plots, animations).

5. Integration and Compatibility

- ✓ **Data Import/Export**: Supported formats for importing and exporting data (e.g., CSV, XML, HDF5).
- ✓ **Software Integration**: Compatibility with other software tools (e.g., CAD systems, data analysis tools).
- ✓ **API Access**: Availability of APIs or SDKs for custom integrations and automation.

6. Support and Documentation

- ✓ **User Documentation**: Comprehensive manuals, tutorials, and online help resources.
- ✓ **Technical Support**: Types of support available (e.g., email, phone, chat, forums), and support hours.

✓ **Training**: Availability of training programs or workshops for users.

8. Licensing and Cost

✓ **Licensing Models**: Options for acquiring the software (e.g., perpetual licenses, subscription-based models).
✓ **Pricing**: Cost structure including any additional fees for updates, support, or additional modules.
✓ **Educational Discounts**: Availability of discounted licenses for academic institutions.

Examples of technical Specifications required for Multisim Software

- **Operating System**: Windows 10 (64-bit), Windows 11 (64-bit)
- **Processor**: Intel Core i5 (minimum), Intel Core i7 (recommended)
- **RAM**: 8 GB (minimum), 16 GB (recommended)
- **Graphics Card**: DirectX 11 compatible, with at least 2 GB VRAM (recommended)
- **Storage**: 10 GB free space for installation, SSD recommended
- **Network**: Required for installation and updates
- **Modelling Capabilities**: Analogy, digital, and mixed-signal simulations
- **User Interface**: Drag-and-drop, real-time waveform analysis
- **Integration**: Compatible with Lab VIEW, Ultiboard; supports various import/export formats
- **Support**: Online documentation, forums, technical support
- **Licensing**: Perpetual, subscription, academic options

Points to Remember

- **Simulation software:**

Refers to a specialized type of simulation software used to model and analyse the behaviour of electronic circuits and systems before building them physically.

- **Versions and features of Simulation Software**

Versions refer to different editions or releases of the software, each offering varying features, capabilities, and levels of support, while

The feature of simulation software is poised to be influenced by several emerging trends and technological advancements.

- **Versions of Simulation software**

  ✓ Free/Basic Version

- ✓ Standard/Professional Version
- ✓ Enterprise/Advanced Version
- ✓ Academic/Research Version
- ✓ Trial Version
- ✓ Open Source Version
- ✓ Legacy/Archived Version

- **Features of circuit simulation software**
  - ✓ Modelling and Design
  - ✓ Simulation Capabilities:
  - ✓ Integration and Interoperability
  - ✓ Collaboration and Sharing.
  - ✓ Scalability and Performance
  - ✓ Validation and Verification
  - ✓ Customization and Extensibility
  - ✓ Security and Compliance
- **Examples of circuit simulation software**
  - ✓ Multisim.
  - ✓ Proteus
  - ✓ Autodesk Eagle
  - ✓ Altium Designer
  - ✓ Ki Cad

- **Technical specifications for simulation software**

Technical specifications for simulation software refer to the detailed characteristics and requirements that define the software's performance, capabilities, and compatibility.

- **The minimum system requirements for running this simulation software**

This includes the minimum hardware specifications such as CPU, RAM, storage, and graphics requirements, as well as the supported operating systems.

Application of learning 1.2.

EASY TECH LTD is an Electronic project manufacturing company. located in NYAMABUYE special economic zone, MUHANGA DISTRICT. The company deals with designing electronic circuits using different electronic simulation software, as a trainee who studied to interpret electronic circuit simulation software, you are asked to identify the simulation software used to draw a 5vdc power supply according to its version and its features.

Indicative content 1.3: Installation of Circuit Simulation Software

Duration: 4hrs

Practical Activity 1.3.1: Installing of MULTSIM Simulation software

Task:

1: You are requested to go in computer lab to download, install and navigate Multism Simulation software IDE
2: Read the key readings 1.3.1 about the installation of Multism
3: By following the steps from key reading, perform the given task
4: Present the work to the whole class/ trainer.
5: In addition, ask questions where necessary and perform the application of learning 1.3

Key readings 1.3.1: Installing MULTSIM Simulation software

Multisim is the schematic capture and simulation application of national instruments circuit
design suite, a suite of EDA (Electronic Design Automation).

Multisim is designed for schematic entry, simulation, and feeding to downstage steps, such as PCB layout.

These are the steps required to install Multism simulation software:

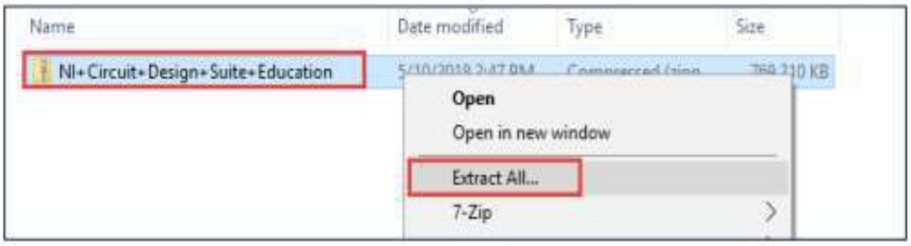
1. Prepare Your System

- ✓ Disable the User Account Controls (set to never notify).
- ✓ Disable your anti-virus software.
- ✓ Disable the pop-up blocker in the browser you are using. Note: You can re-enable these settings

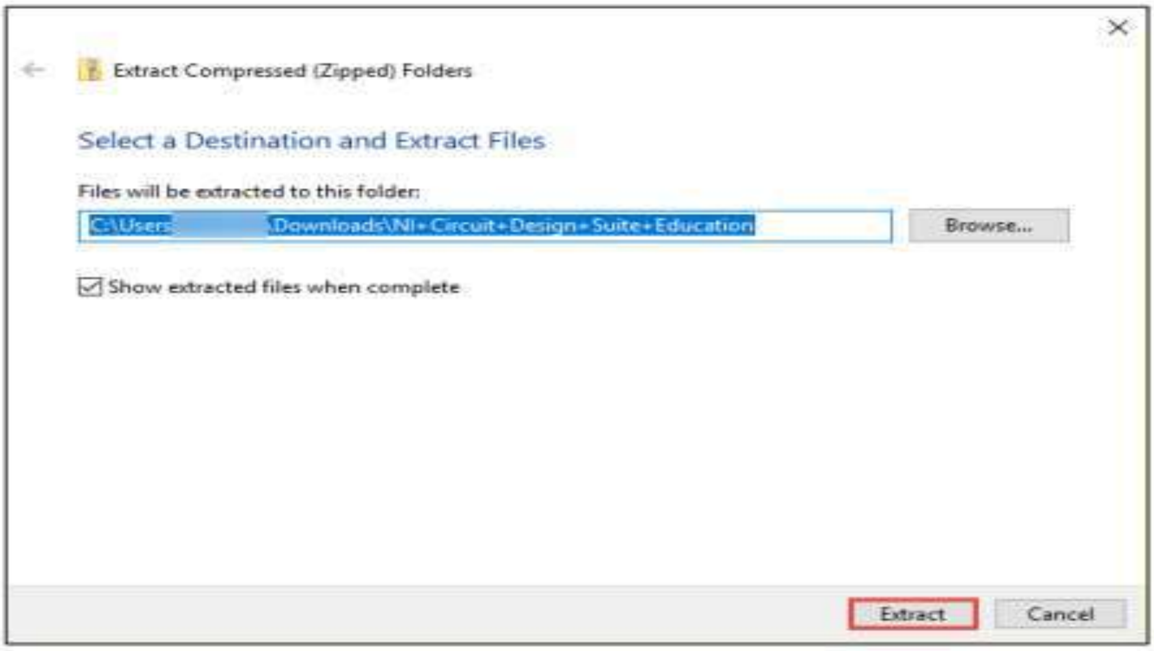
2. Installation of Multism

2.1. Select the following link to download the installer:
https://s3.amazonaws.com/supportdownloads.pltw.org/Installers/Digital+Electronics/NI+Circuit+Design+Suite+Edu cation.zip

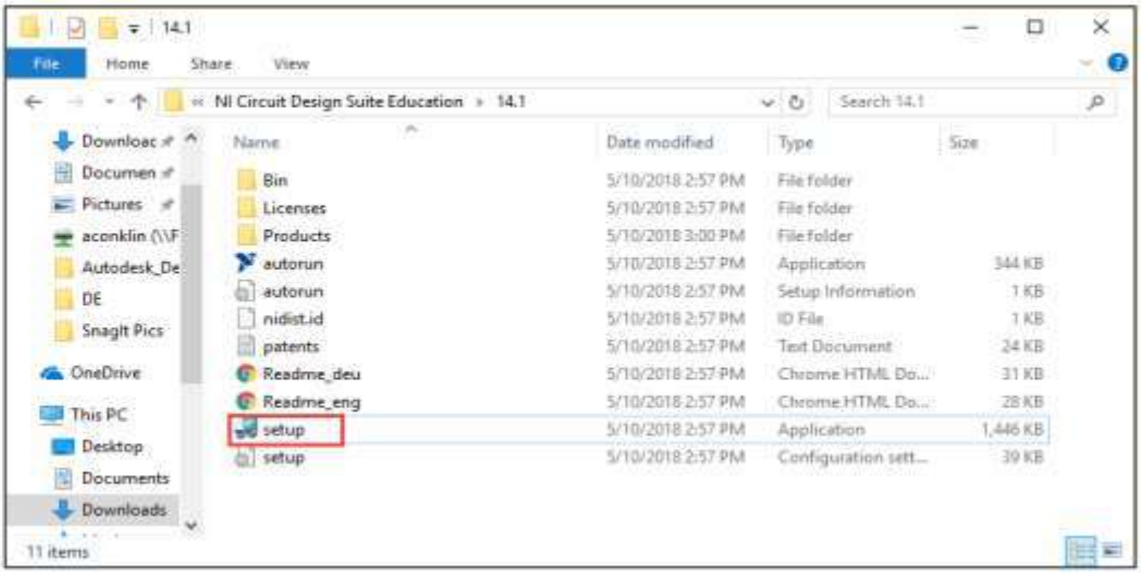
2.2. Go to the downloaded file and extract the .zip file



Choose a location for the installer to extract and begin extraction. Once the extraction is complete, select the next button.



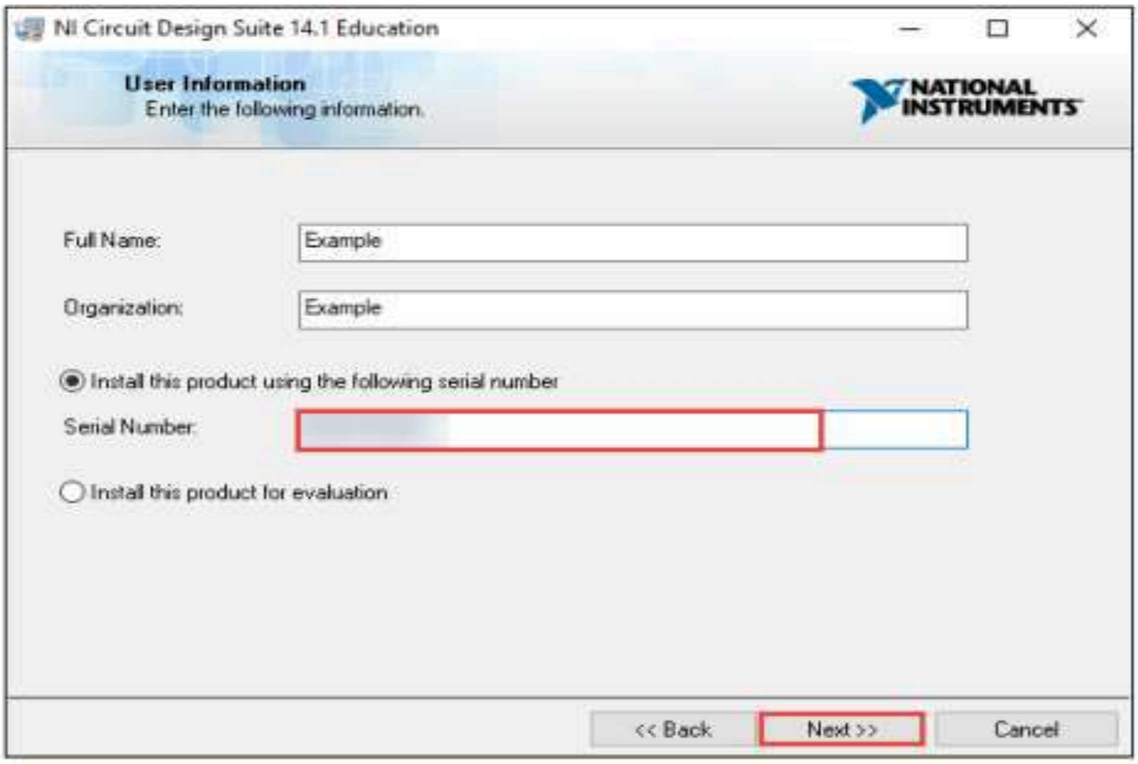
2.3. Open the downloaded folder and click through the folders until you can select setup.



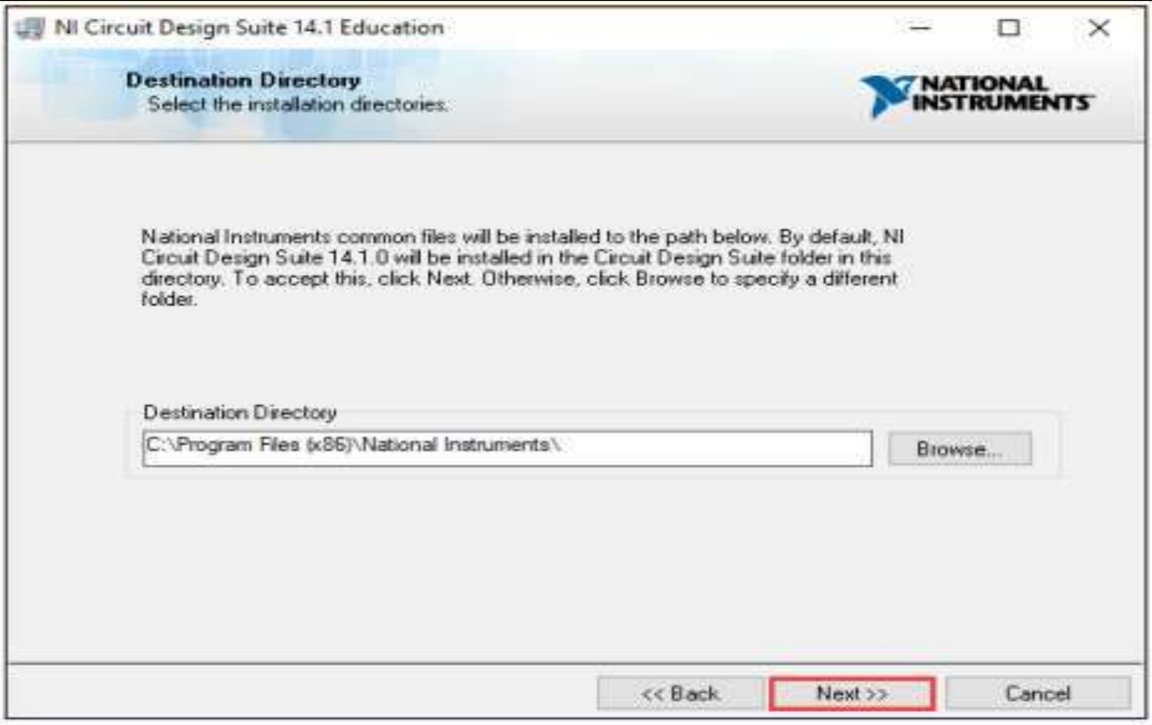
If prompted to allow the software to make changes to your computer, select Run.

2.4. Select next on the installer.

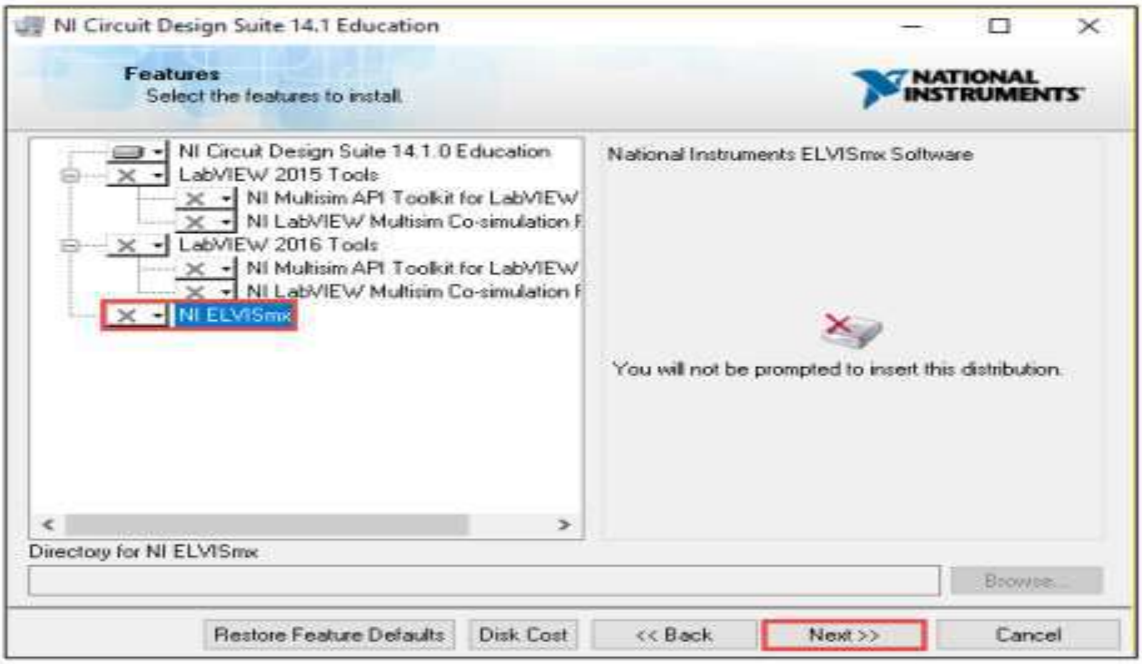
Enter your Name, Organization, and the Serial Number and select next. If you are preparing a master image, select install this product for evaluation. You will need to license after pushing the image to the lab



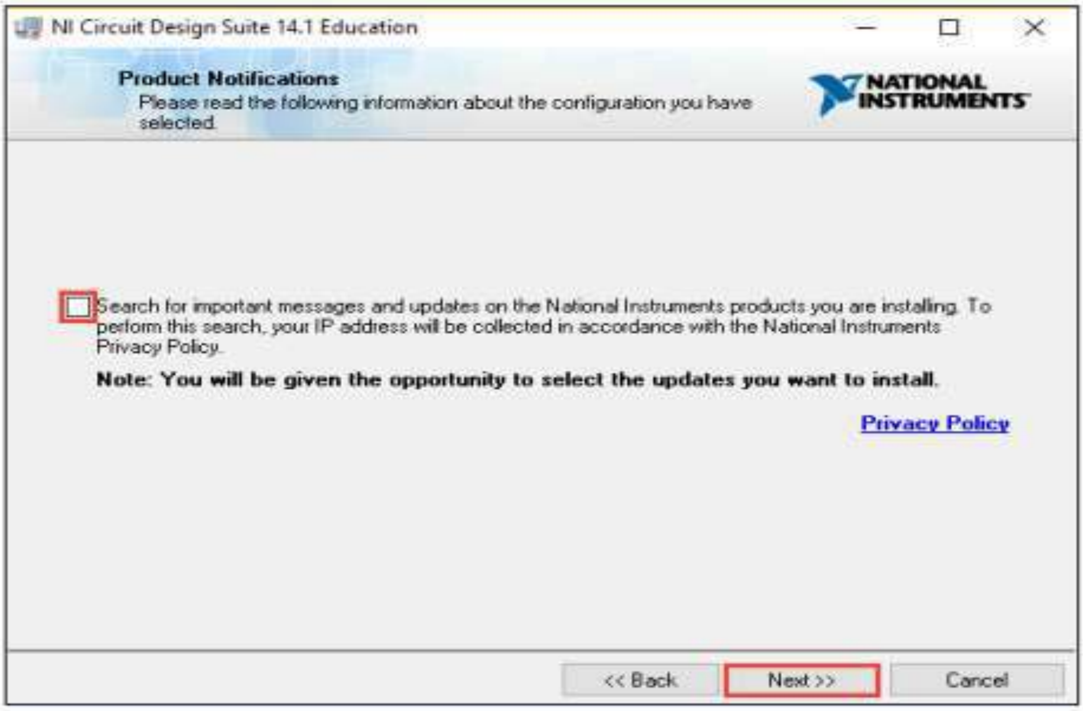
2.5. To keep the default directory, select next.



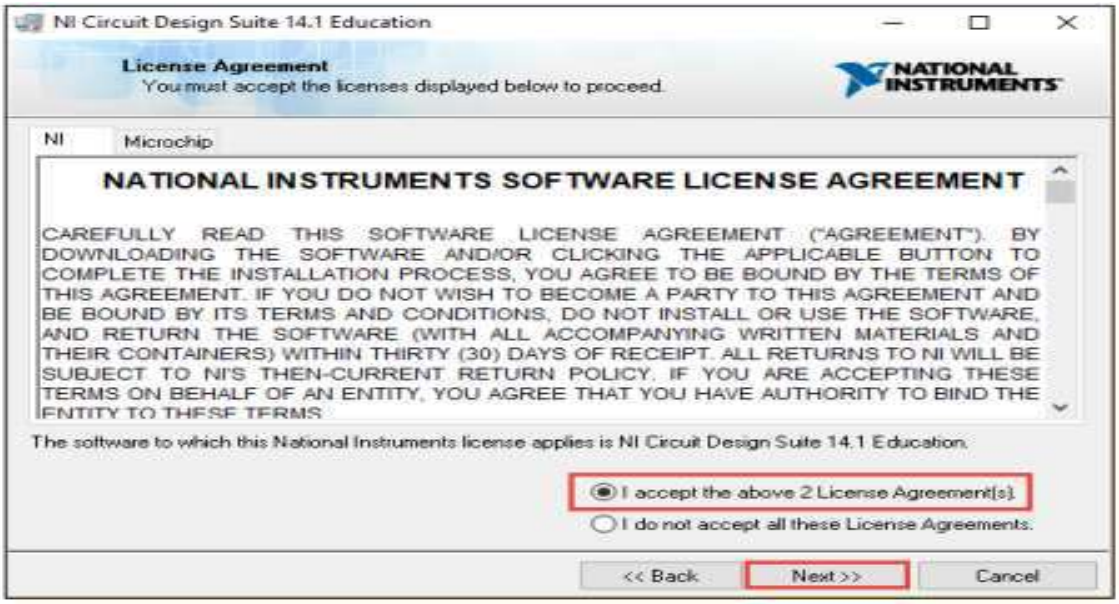
2.6. In the Features window, select Do not install NI ELVISmx, then select Next.



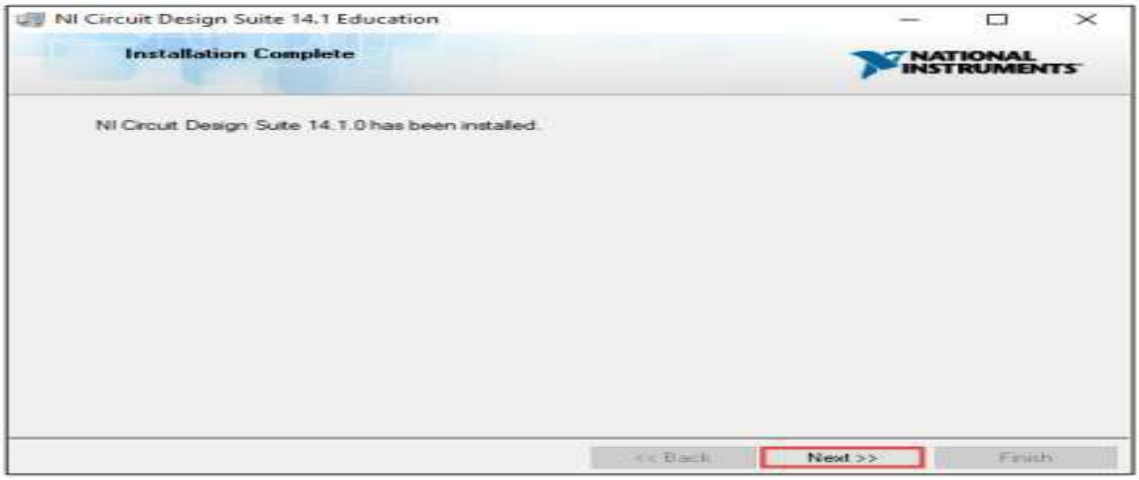
2.6. Clear the check box and select next. Please do not search and make future updates to the software.



- For the License Agreement, select I accept and Next.



When the installation is complete, select Next.



2.7. Select Restart or Restart Later

Practical Activity 1.3.2: Installing Proteus simulation software

Task:

1: You are requested to go in computer lab to download, install and navigate Proteus Simulation software IDE

2: Read the key readings 1.3.2 about the steps for Installing Proteus on your paper/flip chart.

3: By following the steps from key reading, perform the given task

4: Present the work to the whole class/ trainer.

5: In addition, ask questions where necessary and perform the application of learning 1.3

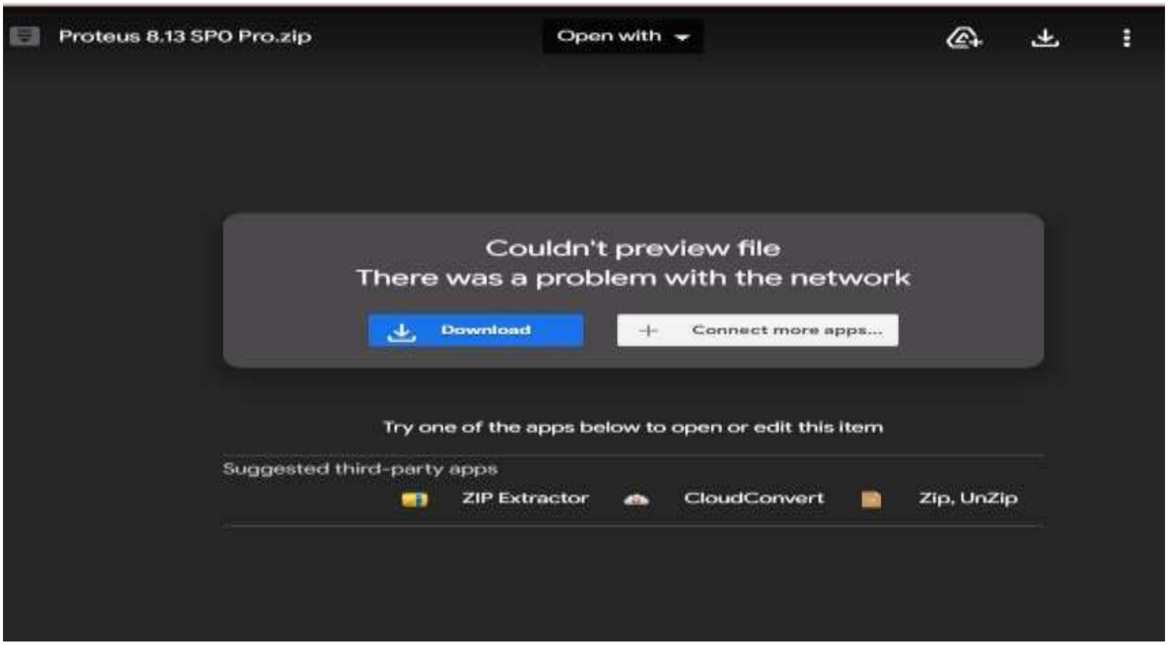
Key readings 1.3.2: Installing Proteus simulation software

1. Check System Requirements

Proteus Software (Proteus 8.13)
Operating System (Windows 7/8/10)
RAM – 3GB
Installation Wizard (Online/Offline)

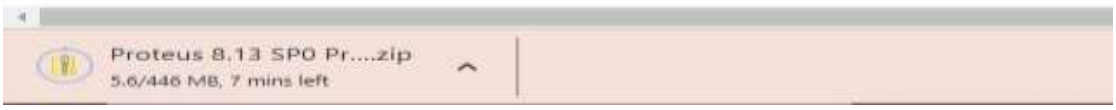
2. Steps to Install Proteus Software in Windows 10

Step 1: First **Download Proteus.** Here we are going to **install Proteus 8.13.** Let's for downloading click on download. It will show the following interface now click on **Download**.

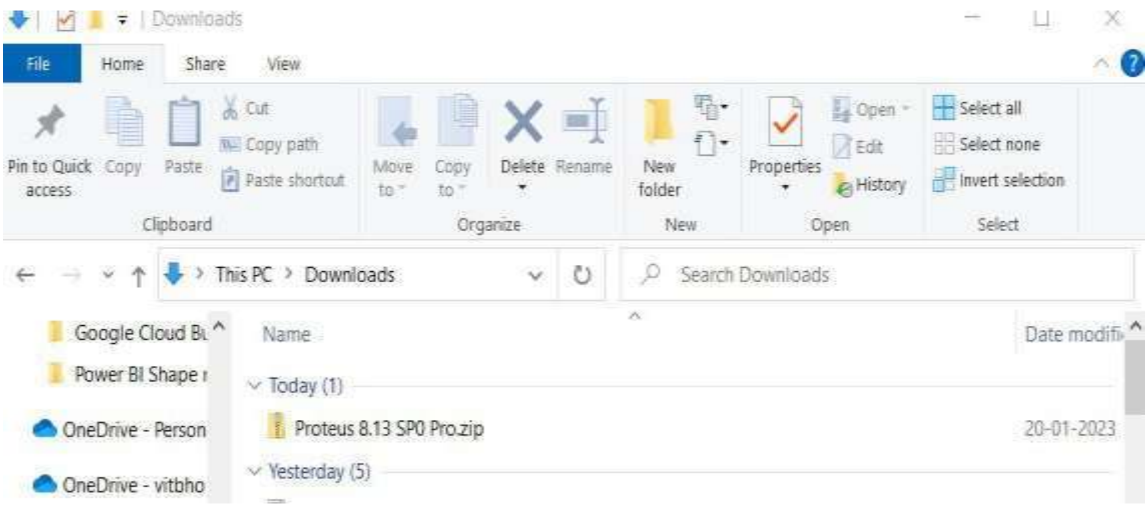


Step 2: In the case of Google drive **it may show the following interface** just click on **Download anyway**.

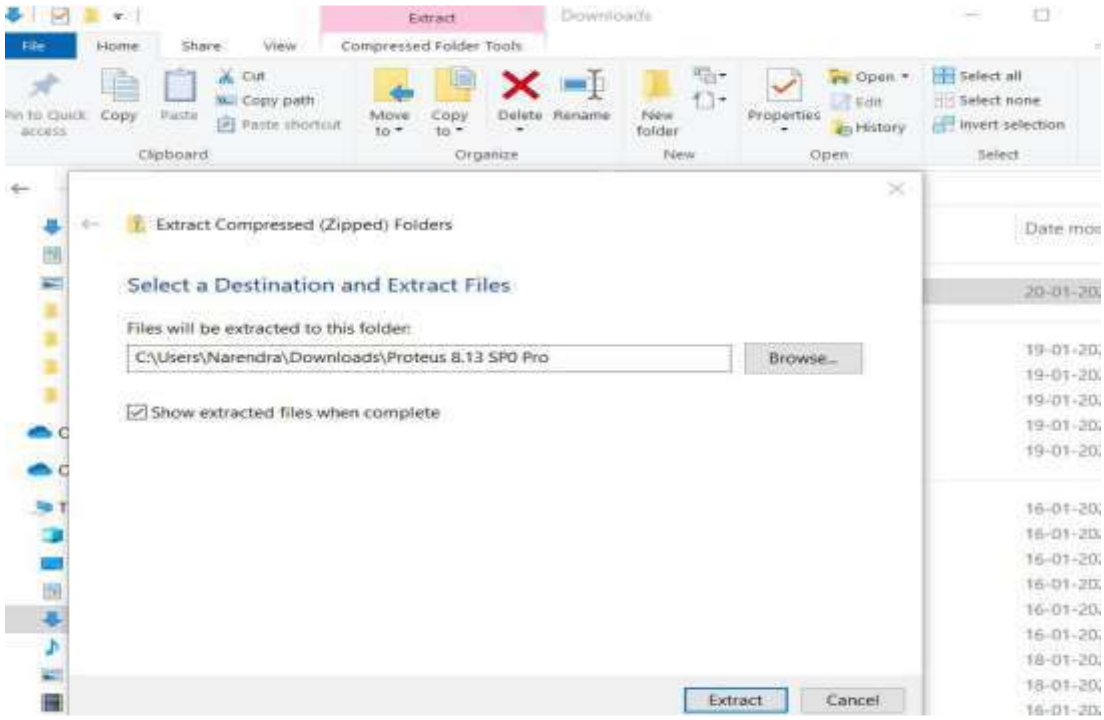
Step 3: It will **start to download the zip file.** Based on your internet speed it will take some time. Wait until the **download process is completed.**



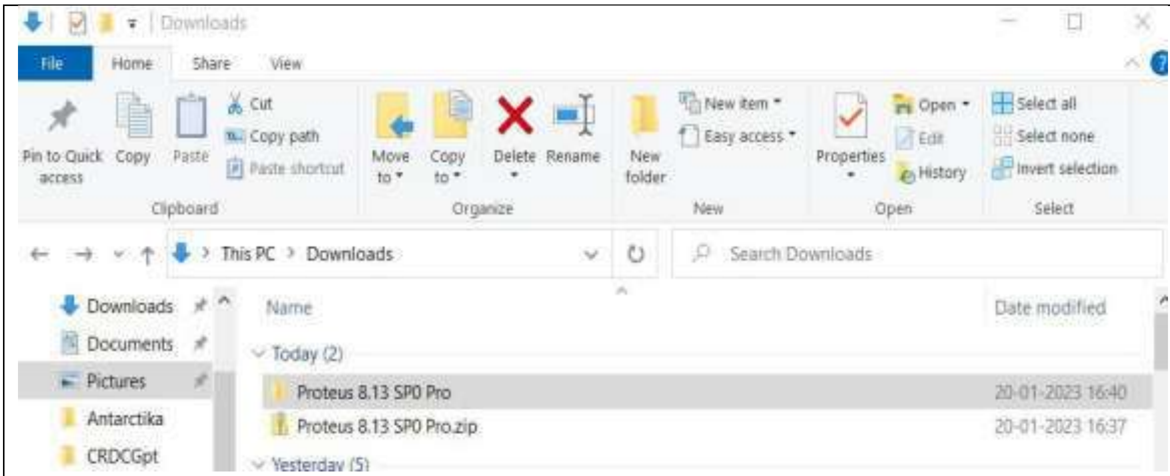
Step 4: When downloading is completed and then **going to the download folder** it will show the zip file.



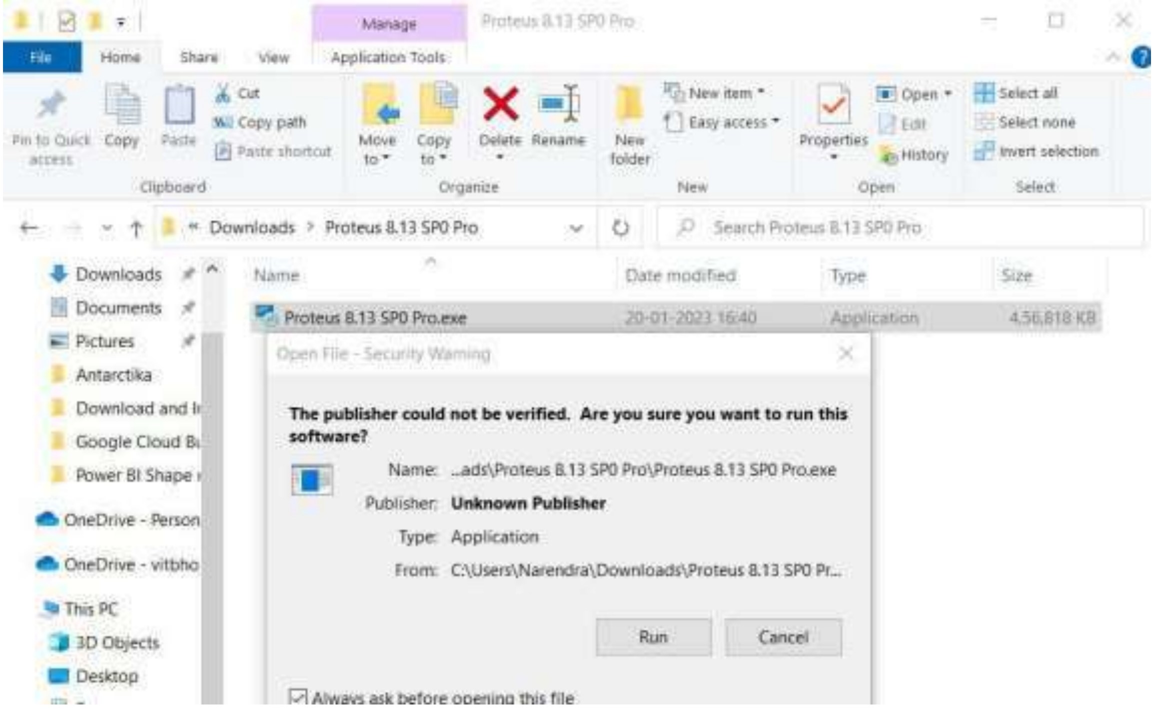
Step 5: Now on **right-click the file** and extract this using whatever software you have to **extract the zip file and select the destination.** Here, browse the location where you want to save.



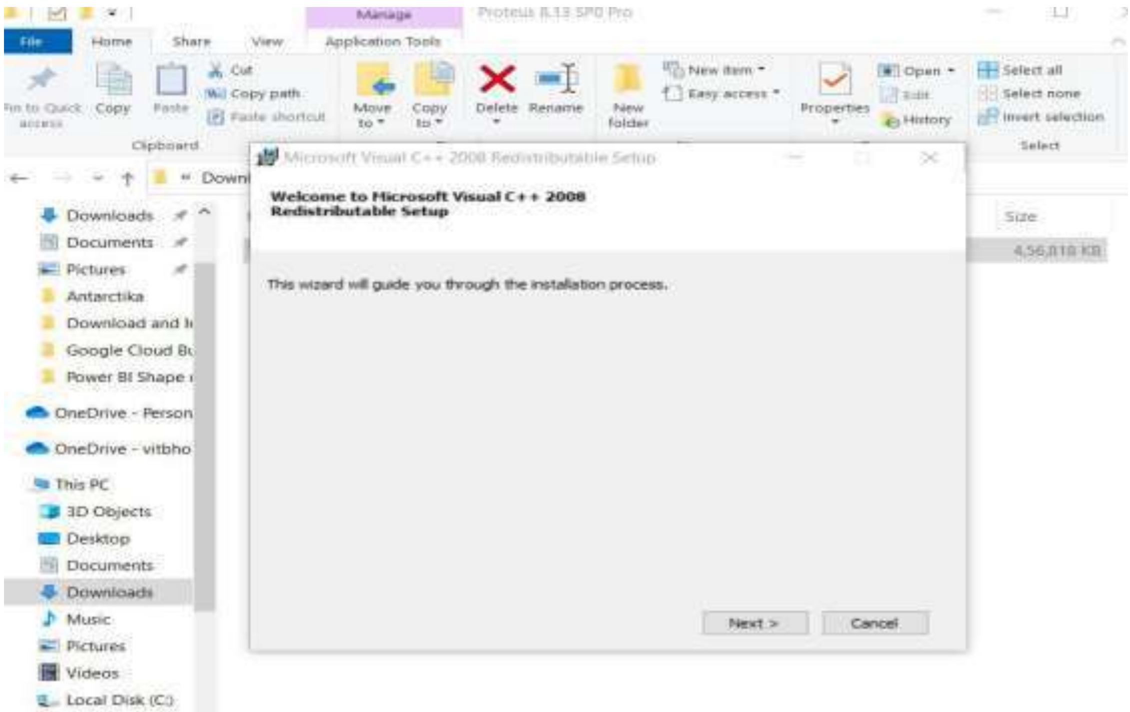
Step 6: Extracted folder will look like this.



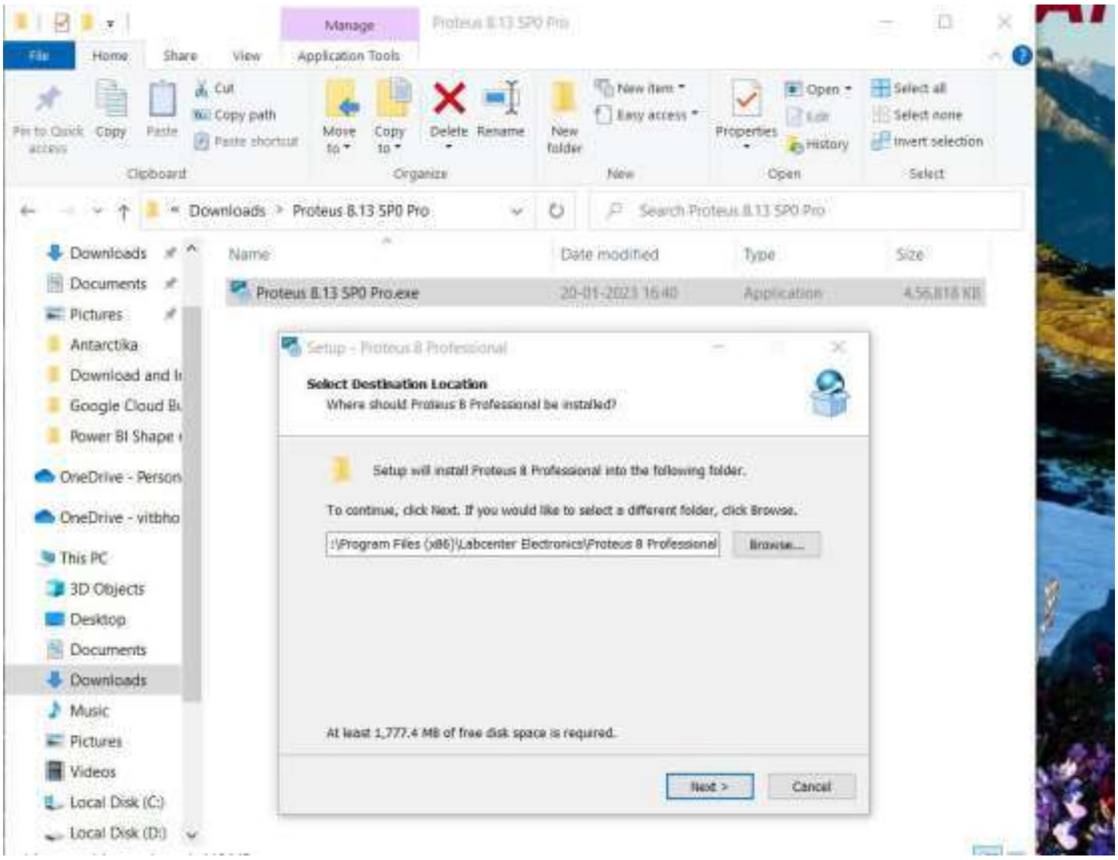
Step 7: Now open **Proteus 8.13 SP0 Pro** Folder and click on the **.exe** file. It will ask to run. Click on **Run**.



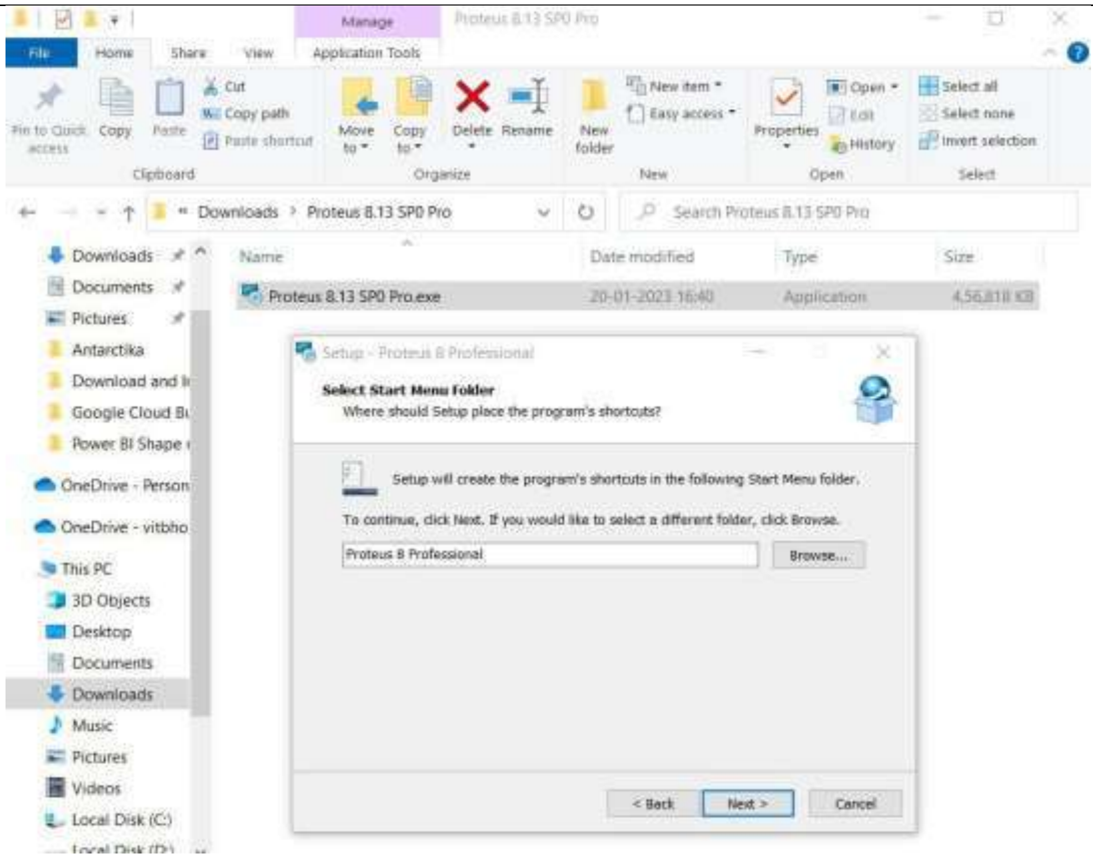
Step 8: In case select you don't have an installation wizard then **first it will ask the Click an install wizard.** Click next and mark check on **Agree**. Then it will install the wizard, it is an **optional process**, if you **already have this wizard then it will go to the next step directly.**



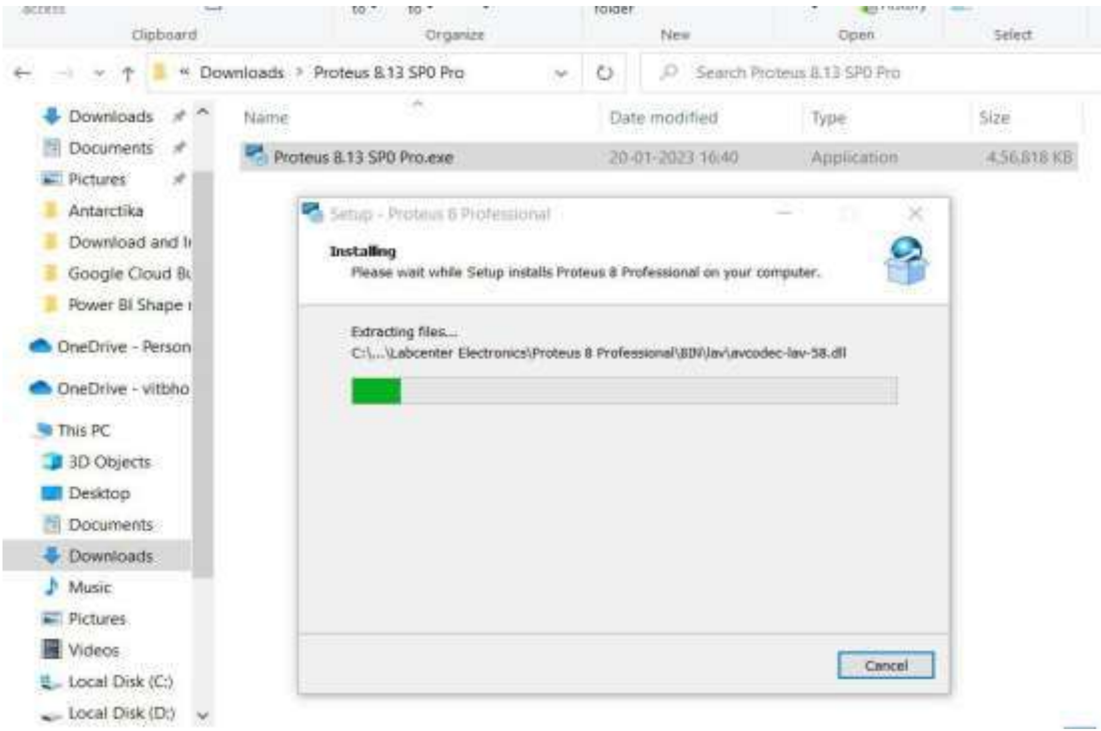
Step 9: Next it will show the following interface and **we need to select the location where we want to install this software.** Click on **Next**.



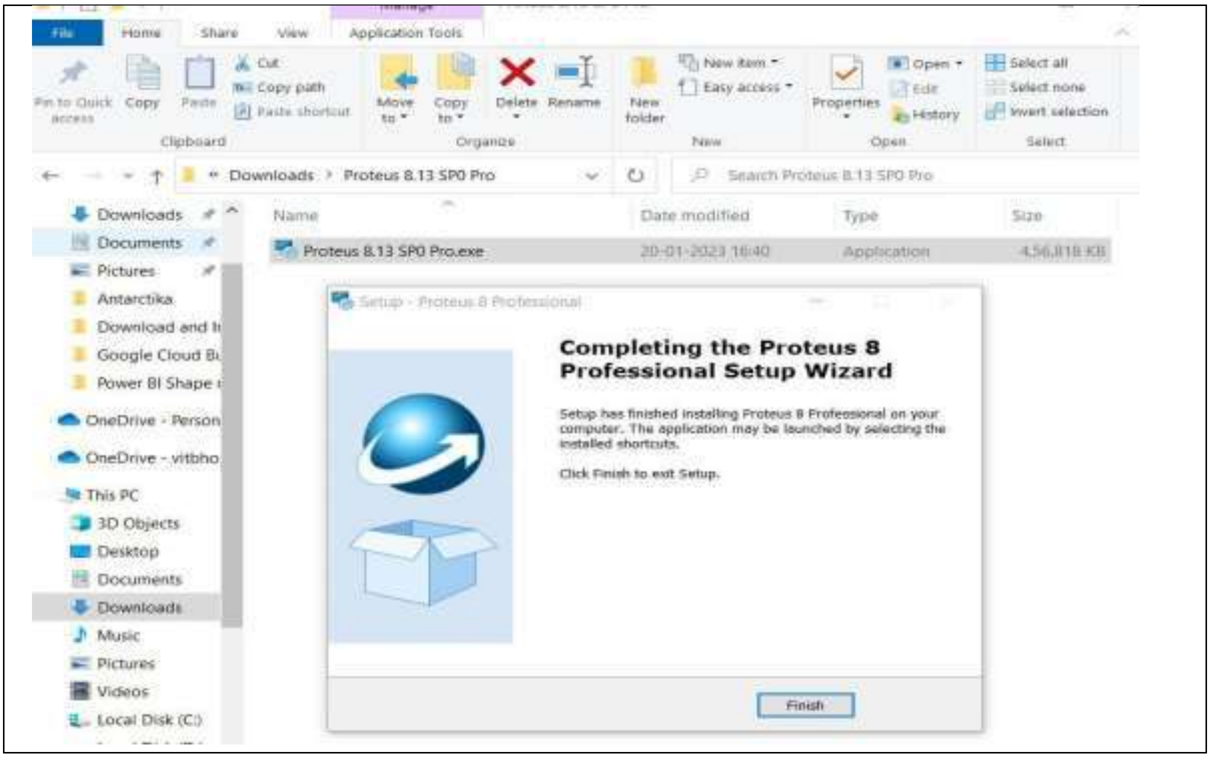
Step 10: Now it will show the **following interface.** Simply click on **Next**.



Step 11: Now it will **start to install.** It will take some time.



Step 12: After **Completion of Installation** it will show the following interface. Simply **Click on Finish.** Our **Proteus 8.13** is **installed in our Windows 10.**



Practical Activity 1.3.3: Installing Autodesk Eagle simulation software

Task:

1: You are requested to go in computer lab to download, install and navigate Autodesk Eagle simulation software

2: Read the key readings 1.3.3 about the steps for Installing Autodesk Eagle simulation software on your paper/flip chart.

3: By following the steps from key reading, perform the given task

4: Present the work to the whole class/trainer.

5: Ask questions where necessary and do the task in the application of leaning 1.3

Key readings 1.3.3:

Installing Autodesk Eagle simulation software

Autodesk Eagle is a popular PCB design software that includes capabilities for circuit design and schematic capture, but it's important to note that Eagle itself does not include a built-in simulation engine like some other tools (e.g., Multisim). However, you can integrate Eagle with simulation tools to analyse and test your circuits.

Steps to install Autodesk Eagle

1. Download Autodesk Eagle

1.1. Visit the Autodesk Website:
Go to the Autodesk Eagle website.
Choose the version you want to download. There are free versions available for students and hobbyists, and paid versions for professionals.

1.2. Sign In or Create an Account:
You'll need an Autodesk account to download the software. Sign in with your existing account or create a new one.

1.3. Download the Installer:
Choose your operating system (Windows, macOS, or Linux) and download the installer.

2. Install Autodesk Eagle

2.1. Run the Installer:
Locate the downloaded installer file (it will be an .exe file for Windows, .dmg for macOS, or a package for Linux).
Double-click the installer file to start the installation process.

2.2. Follow the Installation Wizard:
Language Selection: Choose your preferred language if prompted.
License Agreement: Read and accept the End User License Agreement (EULA).
Choose Installation Location: Select the destination folder for the installation or accept the default location.

2.3. Install: Click "Install" to begin the installation process. Wait for the installation to complete.

2.4. Complete Installation: After installation, you may need to restart your computer. Follow any additional prompts to complete the setup.

2.5. Launch Autodesk Eagle:
After installation, you can start Eagle from the Start Menu (Windows), Applications folder (MacOS), or your application launcher (Linux).

3. Activate Autodesk Eagle

3.1. Sign In:
When you first launch Eagle, you may need to sign in with your Autodesk account to activate the software.

3.1. Enter License Information:
If you have a subscription or license key, enter the required information. For the free version, you may simply need to confirm your student or hobbyist status.

3.2. Integrating with Simulation Tools
Since Eagle does not have built-in simulation capabilities, you can use other software for simulation. Here's how you can integrate Eagle with simulation tools:

3.3. Export Netlist:
In Eagle, create your schematic and layout as usual.
Export the netlist of your design, which is a file that describes the electrical connections in your circuit.

3.4. Choose a Simulation Tool:
Select a compatible simulation tool that suits your needs. Some popular options include:
LTspice**:** A free SPICE simulator from Analog Devices.
Proteus: Offers both PCB design and simulation capabilities.
TINA-TI: A free SPICE simulation tool from Texas Instruments.

Import Netlist:
Import the exported netlist into your chosen simulation tool.
Set up the simulation parameters and run simulations to test and analyse your circuit.

3.5. Analyse Results:
Use the simulation tool's features to analyse the results and make any necessary adjustments to your Eagle design based on the simulation outcomes

3.6. Tips for Using Autodesk Eagle
Use Libraries: Make use of Eagle's extensive library of components or create your own custom libraries as needed.
Community and Support: Utilize Autodesk's forums, documentation, and community resources for additional help and guidance.
Regular Updates: Keep your software updated to benefit from the latest features and improvements.

Points to Remember

- **Multisim:** Is the schematic capture and simulation application of National Instruments Circuit Design Suite, a suite of EDA (Electronic Design Automation) tools that assists you in carrying out the major steps in the circuit design flow. Multisim Is designed for schematic entry, simulation, and feeding to downstage steps, such as PCB layout.
- **Begin the download and the installation**
  - ✓ Visit the download page of Multisim and Download the latest version of Multisim.
  - ✓ Go to the .exe file that was downloaded and launch it. To do this, double-click on it.
  - ✓ Accept the pop-out window. Then, NI Package Installer will launch.
  - ✓ A new window will show up with the NI License Agreement, proceed and accept it, then click Next.
  - ✓ In case your computer has Windows Fast Start-up enabled, proceed to Disable Windows Fast Start-up.
  - ✓ Follow the instructions of the NI Package Installer, you will see the installation progress bar.
- **Proteus simulation software**

It is used to draw, design, and integrate electronic circuits. After designing circuits by taking various parts like Switch, Microcontrollers, LED it also provides to simulate and test designed circuit. After testing in real-time we can go to make this circuit practically in our physical world.

- **The following are steps required to download and install Proteus simulation software**

First, we need to locate a setup of Proteus (Download from internet or on storage device)
Click on the .exe file. It will ask to run. Click on Run.
Now select the location where we want to install this software.
Click on Next and start to install
After Completion of Installation, it will show Proteus interface. Simply Click on Finish.

- **Auto desk Eagle simulation software**

It is electronic design automation (EDA) software that lets printed circuit board (PCB) designers seamlessly connect schematic diagrams, component placement, PCB routing, and comprehensive library content.

- **Steps required to install Auto desk Eagle simulation software**

✓ First, download your installer on the latest version of Auto desk Eagle simulation software
✓ Select the **Run** button to continue.
✓ Select the **Yes** button on the next Windows security dialog box to allow the EAGLE Setup app to make changes to your device.

- ✓ You should now be looking at the **EAGLE Setup wizard**. First, accept the license agreement, then select the **Next** button to continue
- ✓ On the final step of the wizard, select the **Install** button to begin the installation process
- ✓ With your installation complete go ahead and open Autodesk EAGLE.

Application of learning 1.3.

- ❖ EASY TECH LTD is an Electronic project manufacturing company. Located in NYAMABUYE special economic zone, MUHANGA DISTRICT. The company deals with designing electronic circuits using different electronic simulation software, as a trainee who studied to install electronic circuit simulation software, you are asked to install one of the following simulation software (Proteus, Multsim and Auto Desk Eagle).

Indicative content 1.4: Set up Workspaces Environment

Duration: 4hrs

Practical Activity 1.4.1: Setting up the simulation workspace within the software IDE.

Task:

1: As technician you are requested to set up the simulation workspace of one of the following simulation software (Multisim, proteus and Auto desk eagle).

2: Read the key readings 1.4.1 about the steps for setting up the simulation workspace of one of the following simulation software (Multisim, proteus and Auto desk eagle).

3: By following the steps from key reading, perform the given task

4: Present the findings to the whole class.

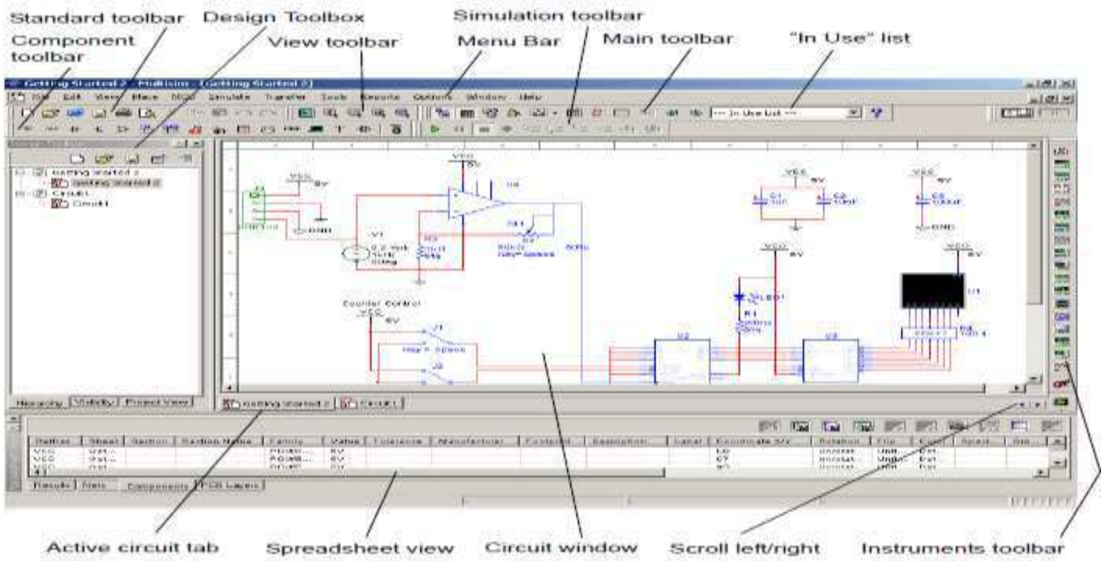
5: In addition, ask questions where necessary

Key readings 1.4.1: Setting up the simulation workspace within the software IDE.

Before setting up the simulation workspace within the software IDE. You have to know:

1. Navigate Simulation software IDE

Multisim's user interface consists of the following basic elements:



- ✓ **Menus** are where you find commands for all functions.

- ✓ **The Standard toolbar contains** buttons for commonly-performed functions.
- ✓ **The Simulation toolbar** contains buttons for starting, stopping, and other simulation functions.
- ✓ **The Instruments toolbar** contains buttons for each instrument.
- ✓ **The Component toolbar** contains buttons that let you select components from the Multisim
- ✓ **Databases for placement in your schematic.**
- ✓ **The Circuit Window** (or workspace) is where you build your circuit design.
- ✓ **The Design Toolbox** lets you navigate through the different types of files in a project (Schematics, PCBs, reports), view a schematic's hierarchy and show or hide different layers.
- ✓ **The Spreadsheet View** allows fast advanced viewing and editing of parameters including component details such as footprints, RefDes, attributes and design constraints. Users can change parameters for some or all components in one step and perform a number of other functions.

2. Create a new project

- ✓ Click on Start
- ✓ All Programs
- ✓ National Instruments Circuit Design Suite 10.0 Multisim.
- ✓ A blank schematic Circuit 1 is automatically created. To create a new schematic
- ✓ click on File – New – Schematic Capture.
- ✓ To save the schematic click on File /Save As.
- ✓ To open an existing file, click on File/ Open in the toolbar.

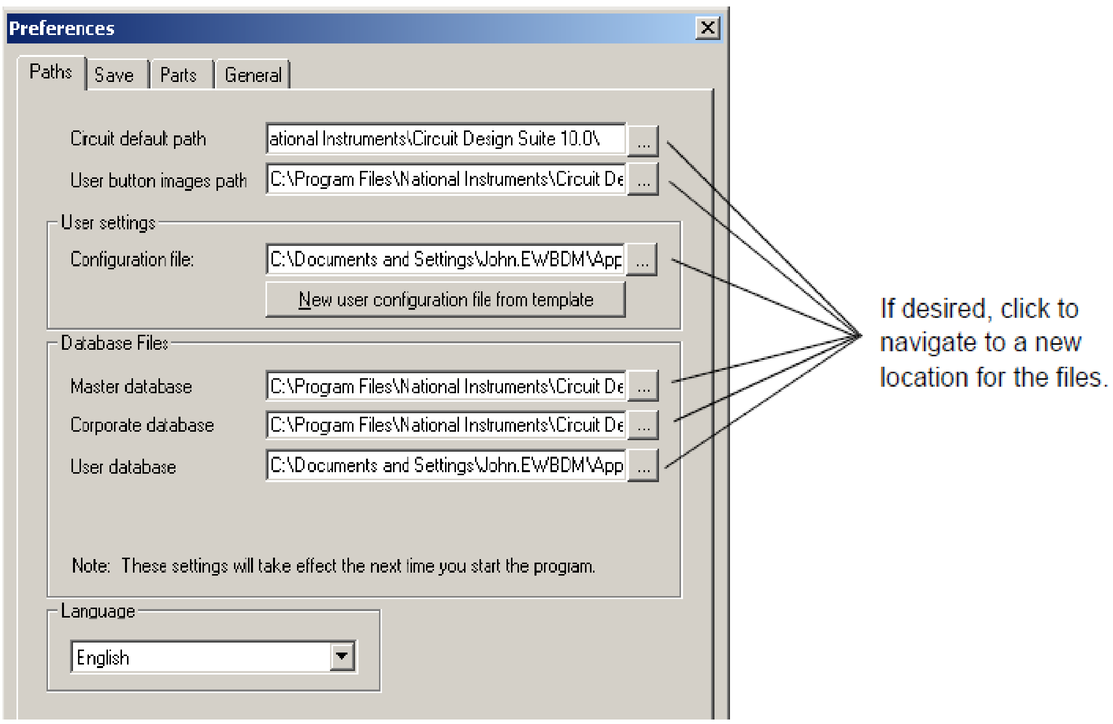
3. Customize Project path

Customize Project Path in a simulation software IDE means setting or altering the directory or location where the files and resources associated with a specific project are saved and managed. This allows you to organize and access your project files more efficiently, ensuring they are stored in a specific folder or drive that best suits your workflow or project requirements.

The Multisim installation puts specific files in specific locations. If necessary, you can point Multisim to a new location to find, for example, database files. You can also use this dialog box to create and specify user settings files that contain individuals' preferences for all Options.

To set up file locations:

1. Choose **Options/Global Preference**. The **Preferences** dialog box appears.
2. Select the **Paths** tab and navigate to the appropriate locations for the different elements.



Note: The most important setting is the **Circuit default path**, as this is where all new files are saved, unless you manually navigate to a new location when saving.

User button Images path is where you store any user-created button graphics.

3. To use a different configuration file, navigate to the appropriate user settings file.

4. To create a new user configuration file, click **new user configuration file from template**. You are prompted to select the configuration file to use as a template, then to enter a name for the new configuration file.

Select an available language in the **Language** box.

4. Customize user interface

Customize User Interface in a simulation software IDE means adjusting the layout, appearance, and arrangement of tools, panels, and menus within the software to suit your personal preferences or workflow needs. This could include rearranging toolbars, changing colors schemes, resizing windows, or adding/removing specific tools and shortcuts to create a more efficient and user-friendly working environment.

The Multisim user interface is highly customizable. Separate customizations can be applied whenever a different type of sheet becomes active. For example, the toolbars and docking Windows can be reconfigure as you move from a circuit sheet to a description sheet.

Toolbars can be docked in various positions and orientations. The contents of the toolbars can be customized. New toolbars can be created. The menu system is fully customizable, including all pop-up menus for the various object types. As well, the keyboard shortcut system is customizable. This allows for any keys or key combinations to be assigned to any command that can be placed in a menu or on a toolbar.

To customize the interface, follow these steps:

1. Select Options/Customize User Interface.

• **"Commands tab"**

To add a command to a menu or toolbar:
1. Drag it from the **Commands** list to the desired menu or toolbar. When a command is Selected in the **Command** list, its description is displayed in the **Description** field.
2. If you do not see the command that you require, click on another selection in the **Categories** list to display more commands.
3. Click **Close** when customizations are complete.

To remove a command from a menu or toolbar, right-click on it and select **Delete** from the pop-up that appears. The **Customize** dialog box must be open when you do this.
To change the position of a command that is in a menu or toolbar, drag it to its new location.
The **Customize** dialog box must be open when you do this.

• **"Toolbars tab"**

The **Toolbars** tab in the **Customize** dialog box is used to show or hide toolbars, and to add new Custom toolbars.
To use the features in this tab:
1. To display a toolbar, switch on the checkbox beside the desired toolbar in the Toolbars list.
2. Switch off a checkbox to hide a toolbar.

Note You cannot switch off the Menu bar.

3.**User the following buttons and checkbox as desired:**
• **Reset all** — displays the **Reset Toolbars** dialog box, where you select whether to reset
The currently selected toolbars, or all toolbars. You are prompted to select the Configuration file you wish to use, for example, "default. ewcfg".
• **New** — displays the **Toolbar Name** dialog box, where you enter the name for a new Toolbar. When you click **OK**, a new toolbar with the name that you entered is created. Follow the steps in "1.6.1 Commands tab" on page 1-31 to add buttons to the toolbar.
• **Rename** — use to rename a toolbar that you have created yourself. You cannot rename toolbars that are included in Multisim by default, for example, Components, Menu Bar.
• **Delete** — use to delete the selected toolbar. You cannot delete toolbars that are included in Multisim by default, for example, Components, Menu Bar.

• **Show text labels** — select this checkbox to show the text labels (for example, “Save”)
In the toolbar, along with the command’s icon.
4. Click **Close** when customizations are complete.

• **“Keyboard tab”**

The **Keyboard** tab is used to set up keyboard shortcuts.
To set up keyboard shortcuts:
1. Choose a category from the Category drop-down list and the desired command from the Commands drop-down list. If a shortcut is already assigned, it appears in the Current keys field.
2. Enter a new shortcut in the Press New Shortcut Key field.
3. Click **Close** when customizations are complete.

• **“Menu tab”**

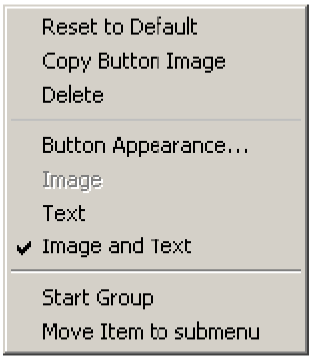
The **Menu** tab is used to modify the various context-sensitive menus that appear when you right-click from various locations in Multisim.
_ To display the desired menu:
1. Select the desired menu set from the Select Context Menu drop-down list.
2. Right-click on the menu that appears and edit as desired.
3. Select the desired menu effects using the Menu animations drop-down list and the Menu shadows checkbox.

• **“Options tab”**

The Options tab in the Customize dialog box is used to set up toolbar and menu options.
_ to set up menu and toolbar options, switch the checkboxes on or off as desired.

• **“Customization Pop-up Menus”**

To customize the appearance of toolbar buttons and menu items, a pop-up menu is available when the customize dialog box is open.



To display the above pop-up:

1. Be sure you have the Customize dialog box open.
2. Right-click on either a menu item or toolbar and select the desired option.
3. When you select Button Appearance, the Button Appearance dialog box appears, where you can change the appearance of the selected tool button.

5. Personalizing Project Path

✓ **For Autodesk Eagle:**

- **Setting Default Project Location:**

Open Eagle: Launch Autodesk Eagle.
Create or Open a Project: Open an existing project or create a new one.
Set Project Directory: To set or change the project directory, go to the “File” menu and select “New Project” or “Open Project”. When creating a new project, choose the desired directory. Unfortunately, Eagle does not have a global setting to change the default project path, so you will need to select the desired location each time you start a new project.

- **Saving and Organizing Projects:**

Save Projects: Use the “File” menu to save projects in the desired directory.
Organize Projects: Create folders within your project directory to keep your files organized.

- **Customizing the Workspace:**

Open Eagle: Launch the Eagle software.
Toolbars and Panels: Customize toolbars and panels by dragging and dropping them to your preferred locations. Right-click on toolbars to show or hide different tools.
User Interface Themes: Eagle does not offer extensive customization for themes or colors, but you can adjust tool visibility and layout to suit your needs.

✓ **For Other IDEs (e.g., LTspice, Proteus):**
✓ **LTspice:**

- **Default File Location:**

Open LTspice: Start LTspice.
Go to Preferences: Navigate to Tools > Control Panel > Draftsman Preferences.
Set Default Paths: Set your preferred directories for saving and accessing files.

- **Customize Toolbars:**

Open LTspice: Launch the LTspice software.
Access Toolbar Customization**:** Right-click on any toolbar and select “Customize”. You can add or remove icons and adjust the toolbar layout.

- **Adjust Preferences:**

Go to Preferences: Navigate to Tools > Control Panel > Draftsman Preferences and adjust settings such as grid size and colors schemes.

✓ **Proteus:**

- **Project Directory Setup:**

Open Proteus: Launch the Proteus software.
Set Project Directory: Go to File > New Project. Choose the directory where you want to save your new project.
Organize Files: You can organize your projects within this directory by creating subfolders as needed.

- **Workspace Layout:**

Open Proteus: Launch Proteus.
Customize Toolbars**:** Right-click on toolbars to show or hide tools. Drag and drop panels to rearrange the workspace.

- **Themes and Colors:**

Go to Preferences: Navigate to Tools > Preferences or File > Preferences to adjust colors schemes and other UI settings.

Note: General Tips for UI Customization:

- ✓ **Explore Settings:** Look for preferences or settings menus in your IDE. Most software offers options to customize toolbars, themes, and layouts.
- ✓ **Save Custom Layouts:** If your IDE supports it, save your customized layout or workspace settings so you can easily return to them or apply them to other installations.
- ✓ **Use Extensions or Plugins:** Some IDEs allow for additional customization through extensions or Top of Form

Points to Remember

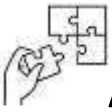
- **Creation of new project of simulation software IDE**

Refers to the setting up of a dedicated workspace within the software where you can start designing, simulating, and managing all aspects of a specific circuit or system. This typically involves:

✓ Naming the project

- ✓ Selecting a storage location
- ✓ Configuring initial settings
- ✓ Organizing the necessary files and components that will be used throughout the design and simulation process.

- When setting up and personalizing the simulation workspace in Multisim Simulation Software IDE, it's important to first create a new project by navigating to the appropriate menu and choosing a location to save your work. Next, configure the project path to ensure that all files are stored in an organized and easily accessible directory. Customize the user interface to suit your workflow by arranging toolbars, panels, and windows in a way that maximizes efficiency. You can also adjust visual settings, such as themes and colours, to make the environment more comfortable for extended use. Finally, save your workspace layout so that it can be quickly loaded in future sessions, ensuring consistency and productivity in your design process.



Application of learning 1.4.

SmartTech Solutions**,** located in the Kigali Tech District, specializes in creating innovative electronic devices. As a trainee experienced in simulation software, you are tasked with setting up the workspace in one of the following Simulation Software (Multisim, proteus and Auto desk eagle) to ensure an efficient and organized environment for circuit design and simulation. This setup will streamline the workflow, allowing the engineering team to focus on high-quality design and testing.

Indicative content 1.5: Selection of Electronic Tools, Components and Equipment

Duration: 4 hrs

Practical Activity 1.5.1: Placing component, tools and equipment within the software IDE.

Task:

1: You are requested to place components, tools and equipment of one of the following simulation software (Multisim proteus and Auto Desk Eagle).

2: Read the **key readings 1.5.1** about the steps of placing components, tools and equipment of one of the following simulation software (Multisim, proteus and Auto desk eagle).

3: By following the steps from key reading, perform the given task

4: Present the work to the whole class.

5: In addition, ask questions where necessary

Key readings 1.5.1: Placing component, tools and equipment within the software IDE.

1. Definitions of terms

- ✓ **Component symbols** are graphical icons used in circuit diagrams to represent electronic components like resistors and capacitors
- ✓ **Tools symbols** represent various electronic tools, such as multimeters or oscilloscopes, used in circuit assembly and testing.
- ✓ **Equipment symbols** depict larger electronic equipment like power supplies or signal generators in circuit diagrams, ensuring they are correctly identified and integrated into the design.

2. Placing component, tool and equipment

2.1 Placing Components

The component browser is used to select parts from the component databases and place them on a circuit. Database, group, and family (for example, Master organize parts Database, Digital Group, TTL Family). Filters are provided as appropriate to narrow lists based on value range and tolerance where applicable. Type-ahead allows you to type a few characters to jump to the component you are looking for. Search capabilities allow you to find parts using generalized wildcard searches throughout all the databases.

2.1.1 To place a component :

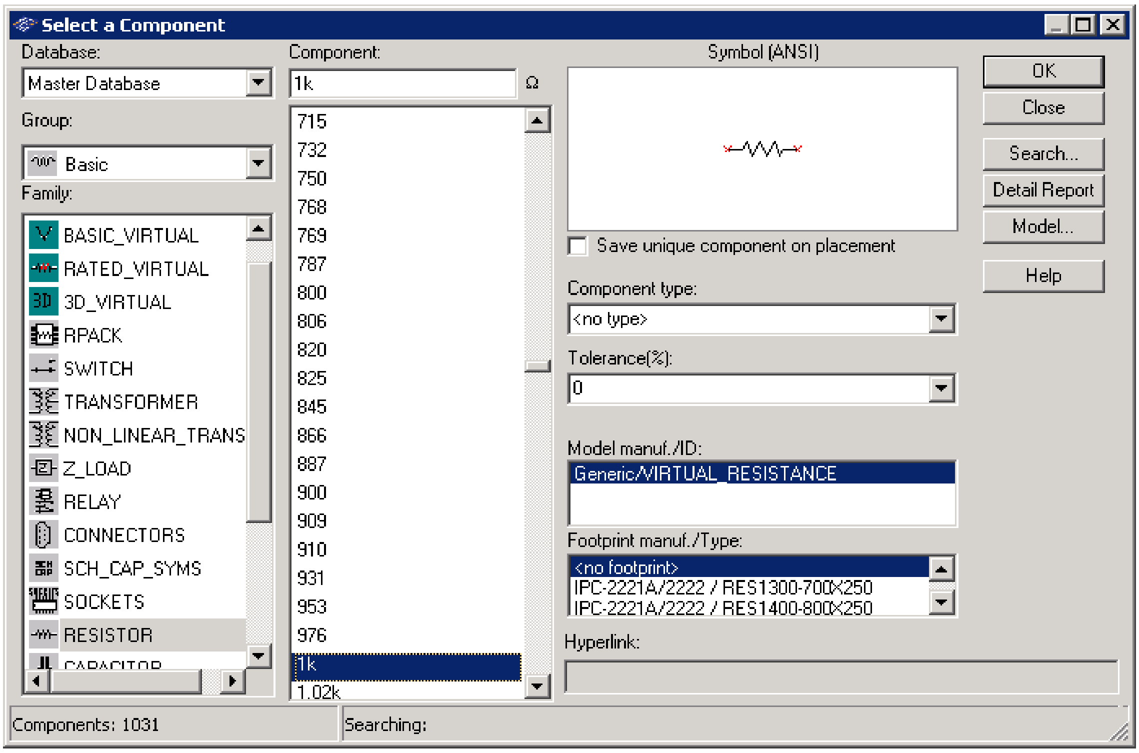
✓ Click on the desired group in the components toolbar, for example, transistor, then select a ccomponent dialog box appears with the selected component group displayed.
Alternatively, you can display the select a component dialog box by choosing place/component and selecting the desired group from the group drop-down list.
Or right-click in the workspace and select place component from the pop-up that appears.
The default database that displays in the browser is the master database. If you wish to select a component from either the corporate database or user database, you must select that database from the database drop-down list before selecting a component. Once changed, the database will remain as selected for subsequent part placements.

- ✓ Click on the desired component family in the Family list.
- ✓ Click on the desired component in the Component list.

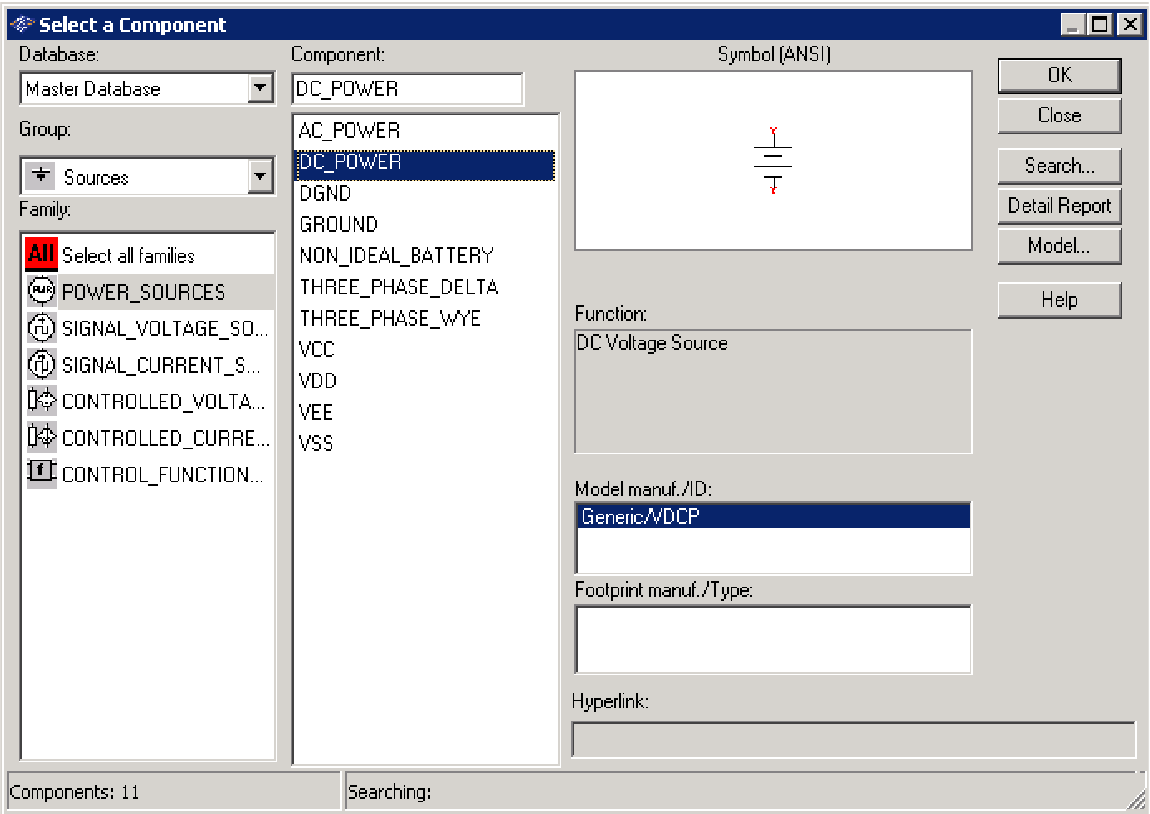
Tip to make you scroll through the component list faster, type the first few characters of the component's name in the Component field. As you type, matches are displayed in the top of the Component list. If you make a mistake, you can use the BACKSPACE key to remove one character at a time, or the DELETE key to remove all of the characters that you typed.

- ✓ Select the desired model and model manufacturer in the Model manuf. /ID area.
- ✓ Selected the desired footprint in the Footprint manuf. /Type list.
- ✓ To confirm that this is the component you want to place, click OK. The browser closes and the cursor on the circuit Windows changes to a ghost image of the component. This indicates that the component is ready to be placed.
- ✓ Move your cursor to the location where you want the component placed. The workspace automatically scrolls if you move your cursor to its edges.
- ✓ Click on the circuit window where you want the component placed. The components

Symbol and labels appear, as well as a unique RefDes made up of a letter and number. The letter represents the type of component and the number is a sequential number that indicates the order in which the components were originally placed. For example, the first digital component has the RefDes "U1", the next is "U2", the first inductor has the RefDes "L1", and So on.



Select a Resistor



Select DC voltage

2.1.2 Rotating/flipping a part during placement

To rotate or flip a part during placement:

1. Select a part
2. As you are dragging the "ghost" image of the part that you are placing, press one of the following key combinations:

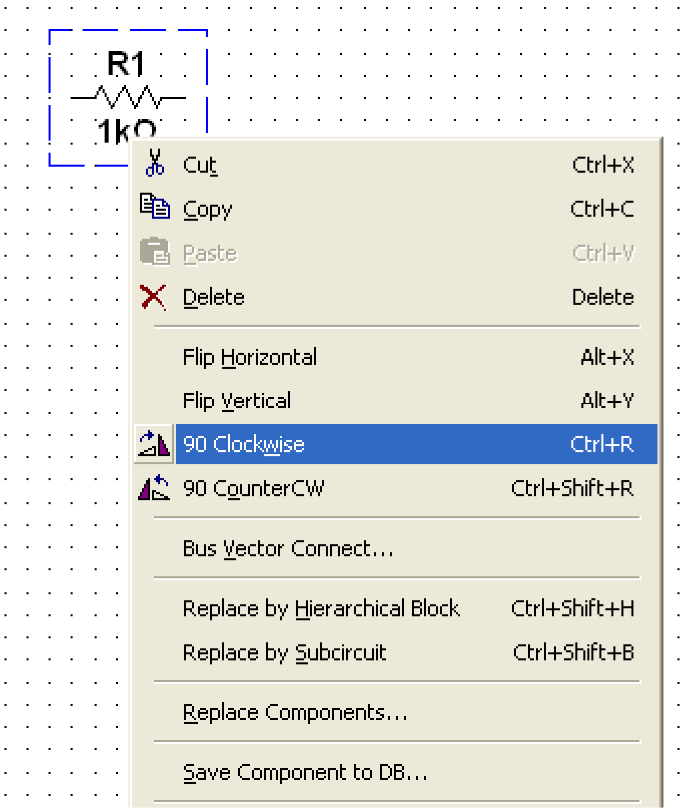
CTRL-R — rotates the component 90 degrees clockwise.

CTRL-SHIFT-R — rotates the component 90 degrees counter-clockwise.

ALT-X — flips the component horizontally.

ALT-Y — flips the component verticall

3. To rotate the components right click on the resistor to flip the component on 90 clockwise (CTRL +R) and 90 counter clockwise (CTRL+SHIFT+R).

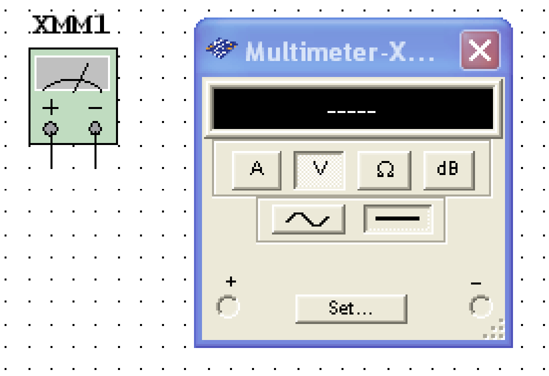


2.2 Equipment symbols

Multisim offers multiple ways to analyze the circuit using virtual instruments. Some of the basic instruments needed for this lab are described below.

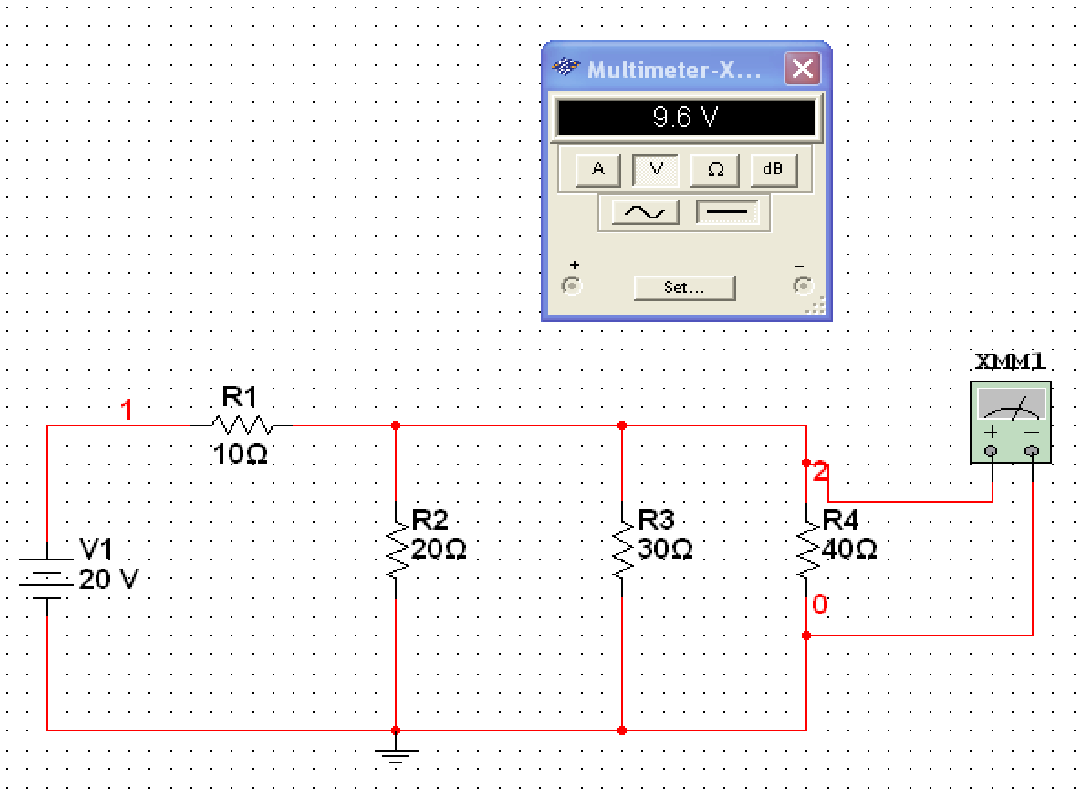
✓ **Multimeter**

Use the Multimeter to measure AC or DC voltage or current, and resistance or decibel loss between two nodes in a circuit. To use the Multimeter click on the Multimeter button in the Instruments toolbar and click to place its icon on the workspace. Double-click on the icon to open the instrument face, which is used to enter settings and view measurements.

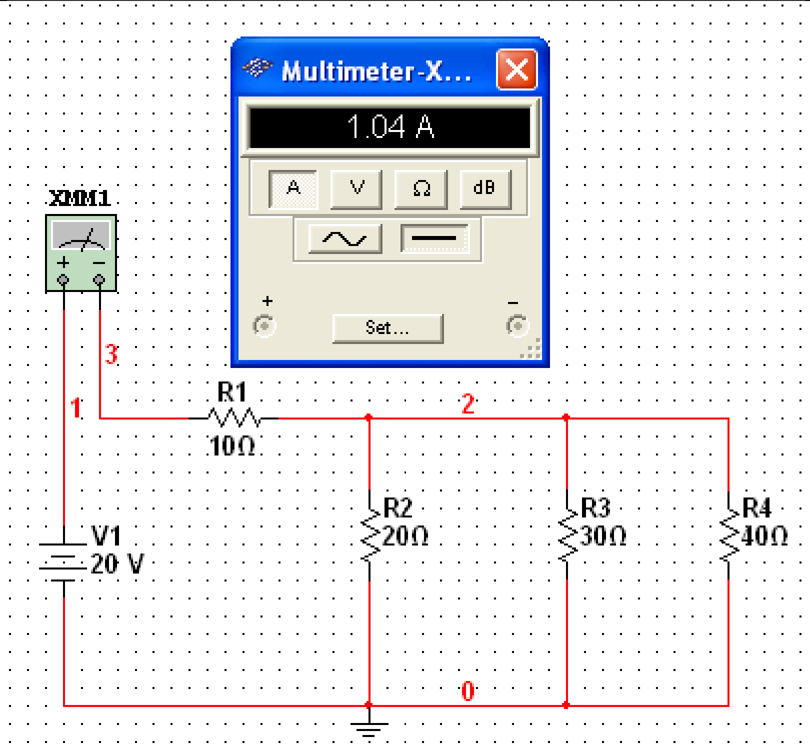


Multimeter

To measure Voltage place multimeter in Parallel with the component (Resistor, Voltage etc.). To measure Current place the multimeter in series with the component.



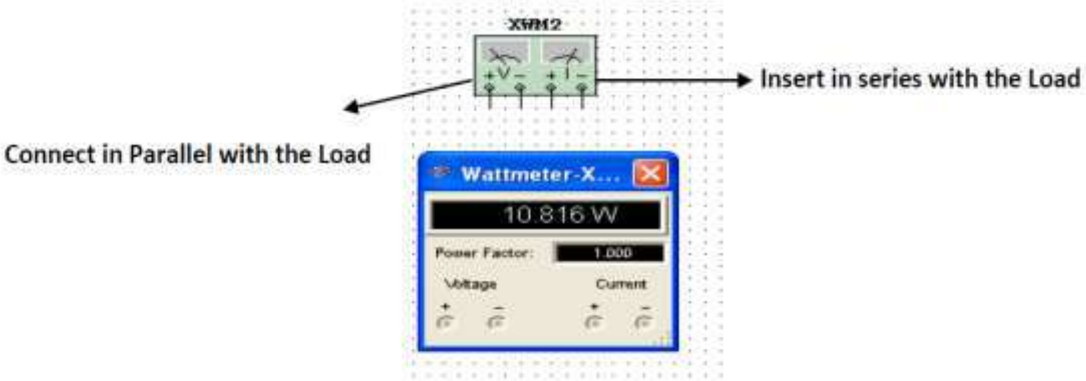
Measure Voltage



Measure Current

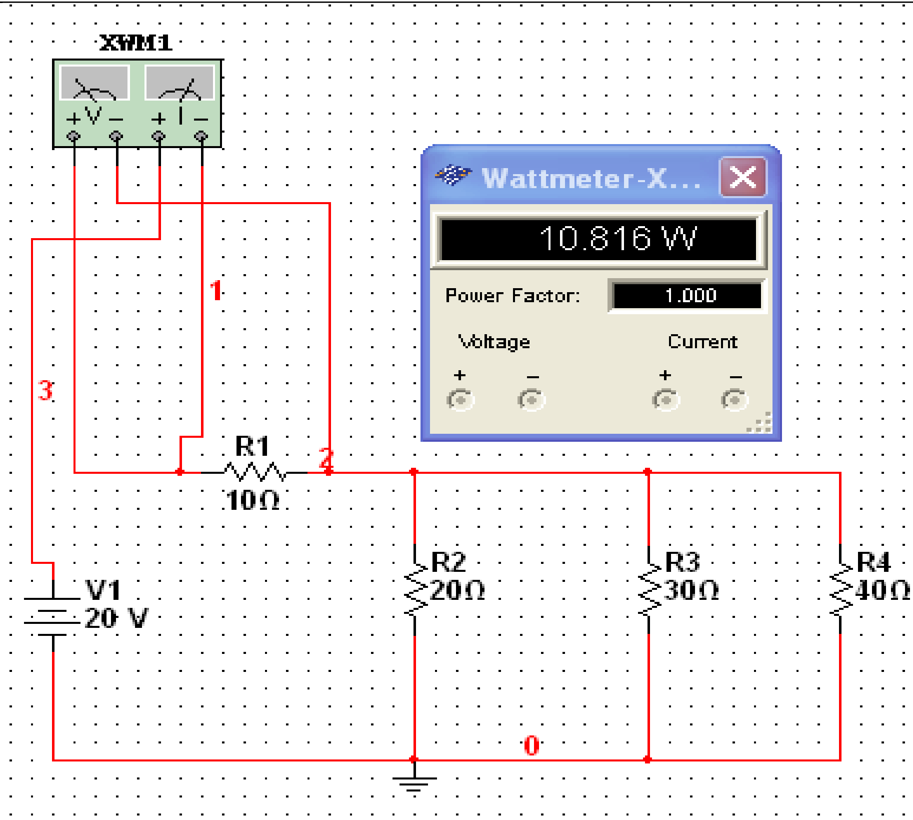
✓ **Wattmeter**

The wattmeter measures power. It is used to measure the magnitude of the active power, that is, the product of the voltage difference and the current flowing through the current terminals in a circuit.



Wattmeter

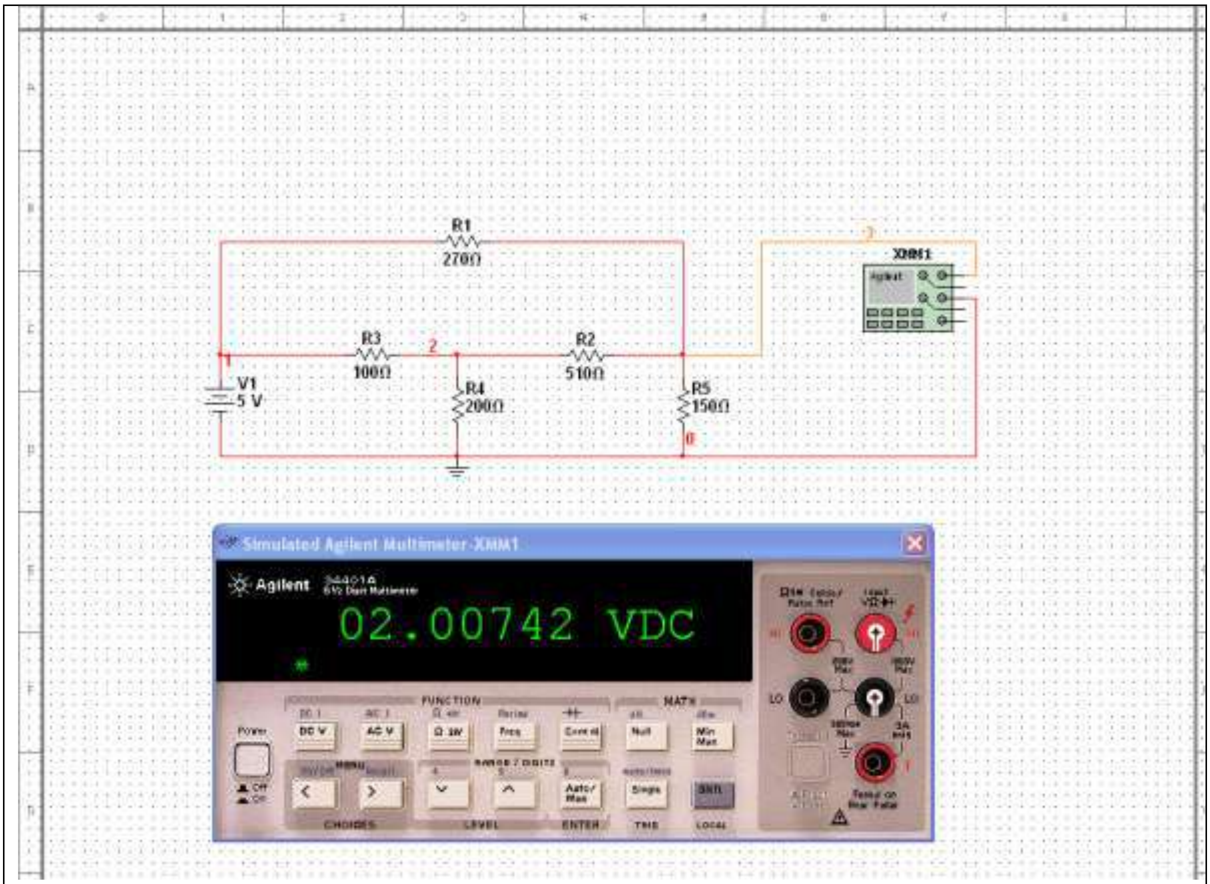
To use the instrument, click on the Wattmeter button in the Instruments toolbar and click to place its icon on the workspace. The icon is used to wire the Wattmeter to the circuit. Double-click on the icon to open the instrument face, which is used to enter settings and view measurements. Reference Figure 15 for more details.



Wattmeter Connections

✓ **Agilent Multimeter**

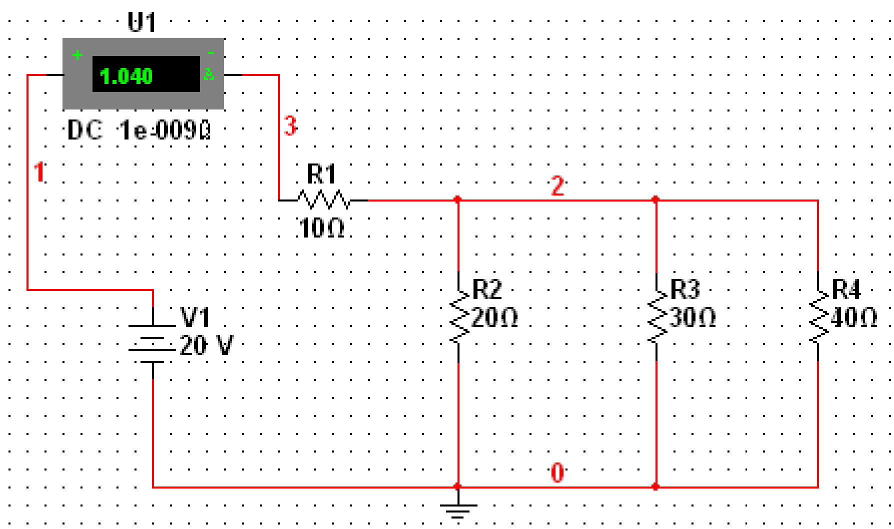
1. The Agilent Multimeter Instrument can also be used to measure and simulate circuits with more accuracy. To use the multimeter click on the Agilent Multimeter tool button, place its icon on the workspace and double-click on the icon to open the instrument. Click on the Power button to switch on the instrument.



Agilent Multimeter.

✓ **Ammeter :**

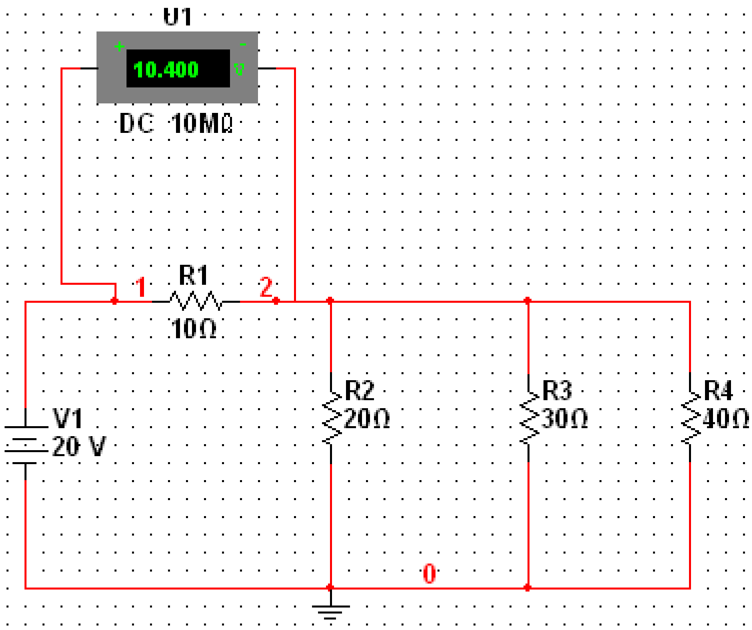
The ammeter offers advantages over the multimeter for measuring current in a circuit. It takes up less space in a circuit and you can rotate its terminals to suit your layout. Always connect the ammeter in series with the load. To place Ammeter, click on View--- Toolbar --- Select Measurement Components.



Ammeter

✓ **Voltmeter**

The Voltmeter offers advantages over the multimeter for measuring voltage in a circuit. Always connect the voltmeter in parallel with the load. The voltmeter can be found in the measurement toolbar.



Voltmeter

Points to Remember

- **Component symbols** are graphical icons used in circuit diagrams to represent electronic components like resistors and capacitors.
- **Tool symbols** represent various electronic tools, such as multimeters or oscilloscopes, used in circuit assembly and testing.
- **Equipment symbols** depict larger electronic equipment like power supplies or signal generators in circuit diagrams, ensuring they are correctly identified and integrated into the design.
- **Placing components, tools, and equipment**
  Placing components, tools, and equipment in the design of an electronic circuit in simulation software involves selecting and positioning the necessary elements onto a virtual circuit board to build and test the circuit.

Application of learning 1.5.

Tech Craft Electronics**,** based in the GISOZI Innovation Hub, specializes in developing custom electronic devices for industrial applications. As a trainee skilled in circuit design, you are tasked with placement of electronic tools, components and equipment within a simulation software IDE.

Indicative content 1.6: Labeling of Electronic Circuit Components

Duration: 3 hrs

Practical Activity 1.6.1 Applying unique labels and electrical values of electronic components within simulation software IDE.

Task:

1: You are requested to apply unique labels and electrical values of electronic components within simulation software IDE.
2: Read the key readings 1.6.1 about the steps for apply unique labels and electrical values of electronic components within of one of the following simulation software (Multisim, proteus and Auto desk eagle).
3: By following the steps from key reading, perform the given task
4: Present the findings to the whole class.
5: In addition, ask questions where necessary

Key readings 1.6.1: Applying unique labels and electrical values of electronic components within simulation software IDE.

1. Definitions

✓ **Assign Labels**: Is Understanding and applying appropriate names or identifiers to each component in a circuit, such as R1 for resistors, C1 for capacitors, etc., to clearly distinguish and reference them in the design.

✓ **Assign Values**: Is Determining and assigning the correct electrical values to each component, such as resistance in ohms, capacitance in farads, or voltage ratings, to ensure the circuit functions as intended.

2. Modifying Component Labels and Attributes

To assign a label or change the Reference Designator (RefDes) of a placed component:

✓ Double-click on the component. The component's properties dialog box appears.
✓ Click the Label tab.
✓ Enter or modify the Label and/or RefDes (which must be composed of letters or numbers only — no special characters or spaces).
✓ Enter or modify the component Attributes (which can be any name or value you choose to give them). For example, you could give the component the manufacturer

name or a name that is meaningful to you such as “new resistor” or “revised May 15”.

✓ Select the component attributes to display by clicking in the Show column. Attributes will be displayed with the component.

Note: If you assign the same RefDes to more than one component, Multisim warns you that this is not possible. Because all RefDes’s must be unique, you must change the RefDes or Cancel before you can proceed.

✓ To cancel your changes, click Cancel. To save your changes, click OK.

2.1. Modifying Net Names

Multisim automatically assigns a net name to each node in the circuit. If desired, you can modify a net name to something more meaningful to the circuit design. For example, you may wish to change a net name to “Output”.

Note: If you are planning to modify net names for certain “global” reserved nets such as Vcc and GND, there are some cautions that apply.

To modify a net name:

- Double-click on the wire. The Net dialog box appears.
- Change the net name as desired.
- To confirm your settings, click OK. To cancel them, click Cancel.

2.2. Adding a Title Block

A powerful title block editor allows you to create customized title blocks. If desired, a title

block can be included on every page of your design. Various fields in the title block are automatically completed depending upon the context and various document properties. When designing the title block, you can choose a pre-defined field or create your own. You choose appropriate fonts depending upon your language of preference.

Title blocks can include elements such as text, lines, arcs, bezier curves, rectangles, ovals,

arcs, bitmaps, and so on.

To add a title block to your circuit:

- Choose Place/Title Block. A standard “Open” dialog box appears. If necessary, navigate to The Title blocks folder.
- Select the desired title block template and click Open. The selected title block appears

attached to your cursor. Drag and drop it in the desired location, typically the lower-right

Corner of the page.

- You can also move the placed title block by right-clicking on it and selecting one of:

  Move to/Bottom Left — places the title block in the bottom-left corner of the Workspace

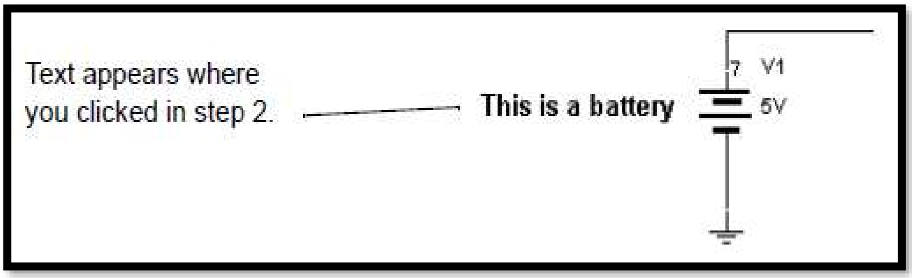
- Move to/Bottom Right — place the title block in the bottom-right corner of the workspace
- Move to/Top Left — places the title block in the top-left corner of the workspace
- Move to/Top Right — places the title block in the top-right corner of the workspace.

2.3. Adding Miscellaneous Text

Multisim allows you to add text to a circuit, for example to label a particular part of a circuit.

To add text :

- Choose Place/Text or right-click on the workspace and select Place Graphic/Text from the pop-up.
- Click on the location where you want the text placed. A text box with a blinking cursor
  Appears.
- Type the text. The text box correctly sizes when you finish typing and click elsewhere in the workspaces.

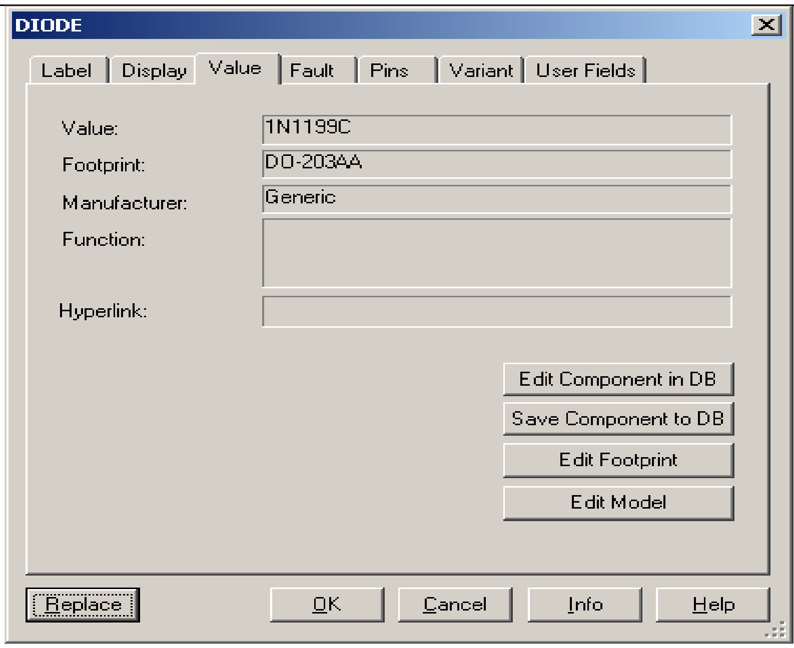


- Click elsewhere on the circuit window to stop adding text.

2.4. Assign Values

To edit the value of a resistor, inductor, or capacitor:

- Double-click on the component and select the Value tab.
- Change the parameters as desired, and click OK.



Note: When working with electronic components in simulation software IDEs, applying unique labels and setting electrical values correctly is crucial for accurate circuit analysis and simulation. Here's a step-by-step guide to help you with this process:

1. **While Assigning Unique Labels consider the followings:**

- ✓ **Identify Components**: Begin by identifying all the components you'll be using in your circuit design. Components might include resistors, capacitors, transistors, ICs, etc.
- ✓ **Open Simulation Software**: Launch your simulation software (such as LTspice, Proteus, KiCad, or any other you are using).
- ✓ **Place Components**: Add the components to your schematic or circuit diagram. Most software allows you to drag and drop components from a library.
- ✓ **Label Components**:
  - **Manual Labelling**: Click on the component and locate the properties or label field. Enter a unique identifier for each component (e.g., R1, R2 for resistors, C1, C2 for capacitors).
  - **Automatic labelling**: Some software can auto-generate labels based on placement order or predefined naming schemes.
- ✓ **Check Consistency**: Ensure that each component has a unique identifier and is consistent throughout the schematic. Avoid duplicate labels as they can cause confusion in simulation and analysis.

2. **While Setting Electrical Values consider the followings:**

- ✓ **Select Component**: Click on the component you wish to set the electrical values for.

- ✓ **Access Properties**: Open the properties or parameters window for the selected component. This is usually accessible by right-clicking on the component or through a dedicated properties menu.

Example of entering values:
Resistors: Enter resistance value (e.g., 10kΩ).
Capacitors: Enter capacitance value (e.g., 100nF).
Inductors: Enter inductance value (e.g., 1mH).
Voltage Sources: Set the voltage value (e.g., 5V).
Current Sources: Set the current value (e.g., 10mA).
Semiconductors and ICs: For more complex components, set relevant parameters such as gain, thresholds, or specific configuration options.

- ✓ **Units and Formats**: Ensure you use correct units and formats. Most simulation software accepts standard units like ohms (Ω), farads (F), henries (H), volts (V), and amps (A).
- ✓ **Save Changes**: Apply and save the changes. Double-check if there's a validation step to confirm the values are correctly entered.

3. **Verifying and Testing**

- ✓ **Run Simulations**: After labeling and setting values, run simulations to ensure the circuit behaves as expected.
- ✓ **Check for Errors**: Look for any errors or warnings in the simulation results or schematic checks. Correct any issues found.
- ✓ **Review Results**: Analyse simulation results to verify that the unique labels and values are producing the desired outcome

4. **Documentation**

- ✓ **Annotate Schematic**: Add annotations or a legend to your schematic to explain the labeling scheme and electrical values, which helps in future revisions or for others reviewing your design.
- ✓ **Maintain a Bill of Materials (BoM)**: If your software supports it, generate a BoM which lists all components along with their unique labels and values.

Points to Remember

- **Assign Labels**: is understanding and applying appropriate names or identifiers to each component in a circuit, such as R1 for resistors, C1 for capacitors, etc., to clearly distinguish and reference them in the design. Follow these steps:
  - ✓ Double-click on the component. The component’s properties dialog box appears.
  - ✓ Click the Label tab.
  - ✓ Enter or modify the Label and/or RefDes
  - ✓ Enter or modify the component Attributes
  - ✓ To cancel your changes, click Cancel. To save your changes, click OK
- **Assign Values**: is determining and assigning the correct electrical values to each component, such as resistance in ohms, capacitance in farads, or voltage ratings, to ensure the circuit functions as intended. Follow these steps:
  - ✓ Double-click on the component and select the Value tab.
  - ✓ Change the parameters as desired, and click OK.

Application of learning 1.6.

Tech Craft Electronics**,** based in the GISOZI Innovation Hub, specializes in developing custom electronic devices for industrial applications. As a trainee skilled in circuit design, you are tasked with applying unique labels and electrical values to electronic components within a simulation software IDE. Your role is to ensure that each component in the circuit is clearly identified and assigned accurate values, such as resistance for resistors or capacitance for capacitors.

Indicative content 1.7: Interconnection of Electronic Components

Duration: 3 hrs

Practical Activity 1.7.1: Applying component terminals orientation, arrangement of components and aesthetics within Multism simulation

Task:

1: You are requested to apply component terminals orientation, arrangement of components and aesthetics, legend and after make test circuit simulation within simulation software IDE.

2: Read the key readings 1.7.1 about the steps for applying component terminals orientation, arrangement of components and aesthetics, legend and after make test circuit simulation within one of the following simulation software (Multisim, proteus and Auto desk eagle).

3: By following the steps from key reading, perform the given task

4: Present the findings to the whole class.

5: In addition, ask questions where necessary.

Key readings 1.7.1: Applying component terminals orientation, arrangement of components and aesthetics within Multism simulation

1. Definition of key terms:

- ✓ **Test Circuit Simulation**: is the process of running a virtual simulation of a circuit design within software to check for correct operation, identify errors, and verify that the circuit functions as intended before physical implementation.
- ✓ **Component Terminals Orientation**: is the specific positioning and alignment of the terminals (or leads) of electronic components, ensuring that they are connected correctly according to their polarity or functional requirements within a circuit.
- ✓ **Arrangement of Components**: is the strategic placement and organization of electronic components on a circuit board or schematic, aimed at optimizing space, minimizing interference, and improving the overall functionality and clarity of the circuit design.
- ✓ **Aesthetics**: The visual appearance and layout of the circuit design, focusing on neatness, symmetry, and clarity to make the circuit easier to read, understand, and troubleshoot.

✓ **Legend**: is a key or guide included in a circuit diagram that explains the meaning of the various symbols, labels, and notations used, helping users to interpret the design accurately.

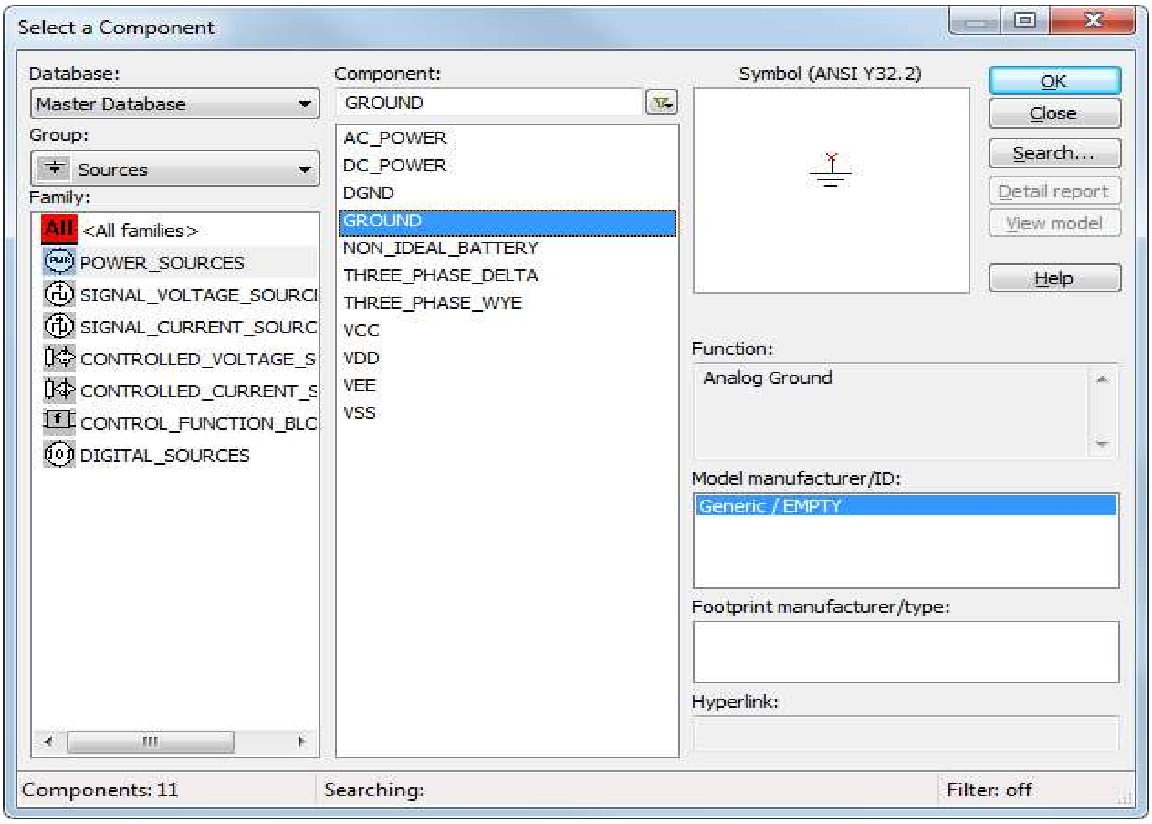
✓ **Test Circuit Simulation**: is the process of running a virtual simulation of a circuit design within software to check for correct operation, identify errors, and verify that the circuit functions as intended before physical implementation.

2. Application of Components Terminals (Polarity)

Begin by drawing your schematic in the Multisim environment.

✓ Open Multisim by selecting **All Programs» National Instruments»Circuit Design Suite 13.0»Multisim 13.0**.

✓ Select **Place» Component**. The **Select a Component** window appears (also known as the **Component Browser**), as shown in Figure below



Select a Component window.

The **Component Browser** organizes the database components into three logical levels. The **Master Database** contains all shipping components in a read-only format. The **Corporate Database** is where you can save custom components to be shared with colleagues. Finally, the **User Database** is where custom components are saved that can be used only by the specific designer.

Additional Points

- ✓ The components (or parts) are organized into **Groups** and **Families** to intuitively and logically group common parts together and make searching easier and more effective.
- ✓ The **Component Browser** shows the component name, symbol, functional description, model, and footprint all in a single pop-up.
- ✓ Select the **Source**s Group and highlight the **POWER_SOURCES** family.
- ✓ Select the **GROUND** component.
- ✓ Click **OK**. The **Select a Component** window temporarily closes and the ground symbol is 'ghosted' to the mouse pointer.
- ✓ Move the mouse to the appropriate place on the workspace and left-click once to place the component. After placing the component, the **Select a Component** window will open again automatically.
- ✓ Go to the **Sources** Group again and highlight the **POWER_SOURCES** Family (if not already highlighted from the previous selection).
- ✓ Select the **DC_POWER** component.
- ✓ Place the **DC_POWER** component on the schematic.

Note: Without a power and ground your simulation cannot run

3.Component arrangement and aesthetics

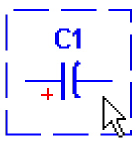
Moving a placed Component

You can move a placed component to another location by doing one of the following:

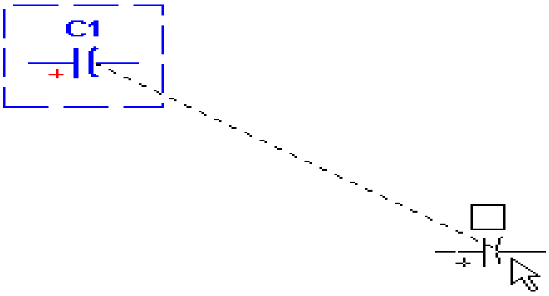
- Dragging the component
- Selecting the component and pressing the arrow keys on your keyboard to move it up, down, or to either side in increments of one grid space.

✓ **To move a component by dragging:**

- Click and hold the left mouse button on the desired component. The component is selected with a dashed line.



- Drag the component to the desired location.

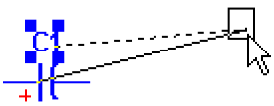


- Release the mouse button when the ghost image is in the desired location.

✓ **To move a component's label:**

- Click and hold the left mouse button on the desired label. The label is selected as illustrated below.

- Drag the component to the desired location.



- Release the mouse button when the ghost image is in the desired location.

✓ **To copy a placed component:**

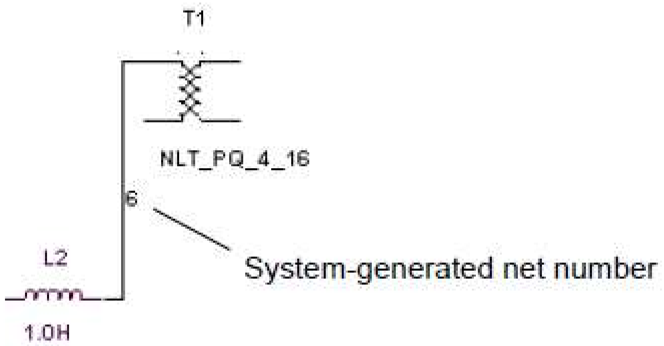
- Select the desired component and choose Edit/Copy. Or Right-click on the desired component, and, from the pop-up menu that appears, choose Copy.
- Select Edit/ Paste. Or Right-click on the workspace select Paste from the pop-up menu that appears.
- The cursor shows a "ghosted" version of the copied component. Click at the location where you want the copied component placed.

4. Wiring Components Automatically

✓ **To wire two components together automatically:**

- Click on a pin from the first component to start the connection (your pointer turns into a crosshair) and move the mouse. A wire appears, attached to your cursor.
- Click on a pin on the second component to finish the connection. Multisim automatically places the wire, which snaps to an appropriate configuration (unless you have disabled the "autowire on connection" option, The wire is numbered as

a net. After a wire is connected between two pins the cursor returns to its normal mode and is ready for your next command.

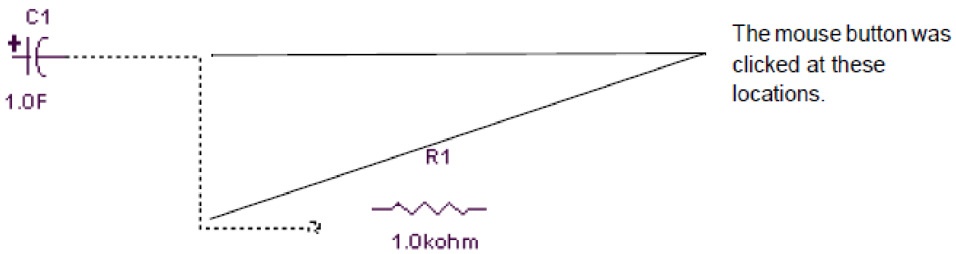


To delete a wire, click on it and press DELETE on your keyboard or right-click on it and choose Delete from the pop-up menu that appears.

✓ **Wiring Components Manually**

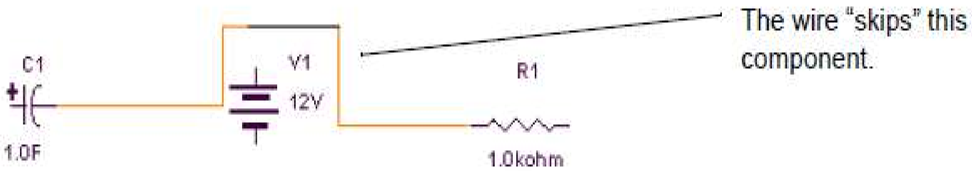
If you want to select the precise path a wire will take on a schematic, use the following procedure:

- Click on a pin from the first component to start the connection (your pointer turns into a crosshair) and move the mouse. A wire appears, attached to your cursor.
- Control the flow of the wire by clicking on points as you move the mouse. Each click "fixes" the wire to that point. For example:



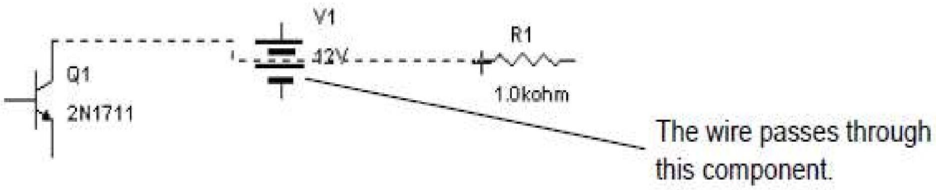
By default, Multisim "skips over" (avoids) components to which it is not connected. For

Exemple :



To pass through intermediary components instead, position the wire at the desired location
beside the intermediary component and press SHIFT on your keyboard while dragging the

wire. For example :



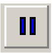
- Click on the desired pin of the second component to finish the connection.

Note: To stop the wiring process at any time, press ESC on your keyboard.
To delete a wire, click on it and press DELETE on your keyboard or right-click on it and choose Delete from the pop-up menu that appears.

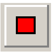
5.Start/Stop/Pause Simulation

To simulate a circuit, click the Run/resume simulation button. Multisim begins to simulate the circuit's behavior. You can also select Simulate/Run.

To pause the simulation while it is running, select Simulate/Pause. To resume the simulation from the same point as when you paused, select Simulate/Run.



To stop a simulation, click the Stop Simulation button or select Simulate/Stop. If you restart thesimulation after stopping it, it will restart from the beginning (unlike Pause, which allows you to restart from the point where you paused).

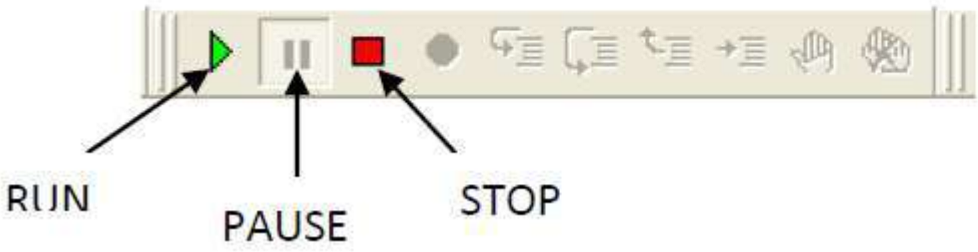


Simulation Running Indicator

To indicate that a simulation is running, the Simulation Running Indicator appears in the status bar as in the example below. This indicator flashes until you stop the simulation. This is especially useful when viewing an instrument that has reached a steady state, such as the

IVAnalyzer.

To simulate the completed circuit, click on Simulate/Run or F5. This feature can also be accessed from the toolbar as shown in the figure below.



✓ **Apply Legend**

A legend is a chart with all of the symbols used in an individual diagram. It could be a mechanical, P&ID, electrical symbol legend, or other types of diagram. This is an invaluable tool because it is not possible to remember every single symbol used in a diagram.

Points to Remember

- **Application of Components Terminals (Polarity)**

Begin by drawing your schematic in the Multisim environment.

1. Open Multisim by selecting All Programs “National Instruments “Circuit Design Suite 13.0»Multisim 13.0.
2. Select Place “Component. The Select a Component window appears (also known as the Component Browser. The Component Browser organizes the database components into three logical levels. The Master Database contains all shipping components in a read-only format. The Corporate Database is where you can save custom components to be shared with colleagues. Finally, the User Database is where custom components are saved that can be used only by the specific designer.

- **Start/Stop/Pause Simulation**

✓ To simulate a circuit, click the Run/resume simulation button. Multisim begins to simulate the circuit’s behavior. You can also select Simulate/Run.

✓ To pause the simulation while it is running, select Simulate/Pause. To resume the simulation from the same point as when you paused, select Simulate/Run.

Application of learning 1.7.

At Brightest Innovations**,** located in the Kigali Tech Hub, you are asked as a trainee to use Multisim simulation software to properly orient the terminals of electronic components, arrange them neatly, add clear labels (legends), and run a test simulation.

Indicative content 1.8: Exporting Circuit Diagram

Duration: 4 hrs.

Practical Activity 1.8.1: Generating project storage location and project file format within simulation software.

Task:

1: You are requested to generate project storage location and project file format within simulation software.
2: Read the key readings 1.8.1 about the steps to Generate project storage location and project file format within simulation software for one of the following simulation software (Multisim, proteus and Auto desk eagle).
3: By following the steps from key reading, perform the given task
4: Present the findings to the whole class.
5: In addition, ask questions where necessary
6: Do the task in the application of leaning 1.8

Key readings 1.8.1: Generating project storage location and project file format within simulation software.

1. Select project storage location.

Project storage location refers to the specific folder or directory on your computer where all the files related to your circuit simulation project are saved.
A **project file format** refers to the specific type of file that the software uses to save and organize all the information related to a circuit design project.

✓ **Introduction to Transfer/Communication**

MultiSim makes it easy to transfer schematic and simulation data to and from other programs for further processing. Multisim can combine schematic information and simulation data for Transfer together. For example, when transferring your schematic to perform a PCB layout, Multisim can include optimized trace width information (calculated using the Trace Width Analysis during simulation).

✓ **File format**

Files with the following formats can be opened with Multisim:
• Multisim 10 Files — *.ms10
• Older Multisim Files — *.ms9, *.ms8, *.ms7, *.msm

• Electronics Workbench 5 Files — *.ewb
• Multisim 10 Project Files — *.mp10
• Older Project Files — *.mp9, *.mp8, *.mp7
• EWB Database Update Files — *.prz
• SPICE Netlist Files — *.cir

2. Saving to a Measurement File

You can save the results of your simulation to either a text-based (.lvm) or binary (.tdm) measurement file, and use applications like National Instruments LabVIEW and DIAdem to
compare simulated output with actual circuit output.

To Save the simulation results as a measurement file:

1. Select View/Grapher. The Grapher appears, showing the results of your simulation and/or analysis.
2. Click the Save to Measurement File button. A file browser appears.
3. Select the desired file type from the drop-down List. Available file types are:
   • Text-based measurement files (*.lvm) — files such as those created in NI LabVIEW.
   • Binary measurement files (*.tdm) — files used to exchange data between National Instruments software, such as LabVIEW and DIAdem.

Note that when you save data as this file type, two files are created: a header file (.tdm) and a binary file (.tdx).

4. Select the desired filepath, enter a filename and click Save. The Data resampling settings
dialog box appears.
5. Change the following settings as desired:

• Do not resample checkbox — appears for .tdm files only. Enable if you do not wish to resample the data. The other options are disabled.
• Resample data checkbox — appears for .tdm files only.
• Interpolation mode — select one of: Coerce; Linear Interpolation; Spline Interpolation. (See “Interpolation modes” on page 9-18 for a description of each).
• Δx (in seconds if time-domain data) — the sampling period to use for resampling.
• 1/Δx (in Hz if time-domain data) — the sampling rate to use for resampling.

Note: You can change either Δx or 1/Δx. The other will change accordingly.

• Estimated file size — this read-only field changes as you change either Δx or 1/Δx.

6. Click OK to close the dialog and save the file.

3. Exporting a Netlist

You can export a netlist for your circuit.

To export a netlist of your design:

1.Select Transfer/Export Netlist. A standard Windows Save As dialog box appears.

2.Select the filepath and file type, enter the filename and click Save. The netlist is saved.

Note: When opening files from earlier versions of Electronics Workbench or Multisim, Reference Designators may be renamed to ensure that all instances are unique.

To open a file of any of the above-listed types except Ulticap:

1. Select File/Open. A standard Open dialog box displays.
2. Select the desired file type from the Files of Type drop-down list.
3. Highlight the desired file and click Open. The file is opened in Multisim.

To open an Ulticap schematic file:

1. Select File/Open. A standard Open dialog box displays.
2. Select the desired file type from the Files of Type drop-down list.
3. Highlight the desired file and click Open. The Ulticap Import dialog displays.
4. Select the desired options in the Save to Database Options box:
    - Do not save imported parts — imports the Ulticap parts without saving them to any of the Multisim databases.
    - Save imported parts — saves the imported Ulticap parts to the selected Multisim Database.

Points to Remember

- **Project storage location** refers to the specific folder or directory on your computer where all the files related to your circuit simulation project are saved.
- A **project file format** refers to the specific type of file that the software uses to save and organize all the information related to a circuit design project.
- **File format** within Multisim **includes :**
    - ✓ Multisim 10 Files — *.ms10
    - ✓ Older Multisim Files — *.ms9, *.ms8, *.ms7, *.msm
    - ✓ Electronics Workbench 5 Files — *.ewb
    - ✓ Multisim 10 Project Files — *.mp10
    - ✓ Older Project Files — *.mp9, *.mp8, *.mp7
    - ✓ EWB Database Update Files — *.prz
    - ✓ SPICE Netlist Files — *.cir
    - ✓ Orcad Files — *.dsn
    - ✓ Ulticap Files — *. utsch

Application of learning 1.8.

At Brightest Innovations in the Kigali Tech Hub, you are tasked with designing and simulating a 5 Vdc power supply for cell phone using one of the following simulation software (Multisim**,** proteus and Auto Desk Eagle). Your responsibilities include designing circuit and running test simulations to validate performance. Additionally, you must create an organized project storage system and generate appropriate file formats for efficient collaboration, documentation, and future updates.

Learning outcome 1 end assessment

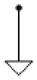
Written assessment

1. The following are some popular software tools used for simulating electronic circuits EXCEPT (Circle correct answer):
   A. Multisim.
   B. Proteus
   C. Autodesk Eagle
   D. NI circuit
   E. Features
2. Read he following statement and answer by **TRU**E if is correct otherwise by **FALSE**
   A. Creation of new project of simulation software IDE refers to the setting up of a dedicated workspace within the software where you can start designing, simulating, and managing all aspects of a specific circuit or system.
   B. When setting up and personalizing the simulation workspace in Multisim Simulation Software IDE, it is not important to first "Create a new project by navigating to the appropriate menu and choosing a location to save your work".
   C. An electronic circuit is the combination of different active and passive components which form an electrical network.
   D. An electronic circuit is the tangible, real-world elements used to construct electronic projects.
   E. An electronic circuit is the combination of different active and passive components which don't form an electrical network.

3. Complete the following using: component symbol, tool symbol and equipment symbol
   A. …………………… are graphical icons used in circuit diagrams to represent electronic components like resistors and capacitors.
   B. …………………… depict larger electronic equipment like power supplies or signal generators in circuit diagrams, ensuring they are correctly identified and integrated into the design.
   C. …………………….. represent various electronic tools, such as multimeters or oscilloscopes, used in circuit assembly and testing.

4. List the steps required to label and assign values to electronic components in the design of electronic circuit in any simulation software?

5. Match the symbol column **A** to its corresponding description to the column **B**.

Column **A**	Column **B**
1. 	A. Single Cell
2. 	B. Potentiometer (IEEE Design)
3. 	C. Digital Ground
4. 	D. Fixed Resistor (IEEE Design)
	E. Semiconductor Diode

Practical assessment

You are a junior electronics engineer at TECHNOVA Solutions**,** a company specializing in the development of consumer electronics. Your team is working on a new portable audio amplifier, and you have been assigned to design and simulate a key component of the 5vdc power supply: a 5vdc power supply will allow only 5vdc pass through, while powering internal component of audio amplifier. Your task is to present out all steps required to design a 5vdc power supply in Multism, simulate its performance, and document your findings for review by the senior engineering team.

END

References

Circuits, A. A. (n.d.). *How to Build a Simple Circuit*. Retrieved from All About Circuits: https://www.allaboutcircuits.com/projects/how-to-build-a-simple-circuit/

Circuits, A. A. (n.d.). *Troubleshooting Circuits: Basics and Testing*. Retrieved from All About Circuits: https://www.allaboutcircuits.com/technical-articles/troubleshooting-circuits-basics-and-testing/

Digest, C. (n.d.). *Basic Electronics Projects for Beginners*. Retrieved from www.Circuit Digest.com: https://circuitdigest.com/electronic-circuits

Digest, C. (n.d.). *Top 10 Basic Electronics Troubleshooting Techniques*. Retrieved from Circuit Digest: https://circuitdigest.com/article/top-10-basic-electronics-troubleshooting-techniques

Digest, C. (n.d.). *Top 10 Basic Electronics Troubleshooting Techniques*. Retrieved from www.Circuit Digest.com: https://circuitdigest.com/article/top-10-basic-electronics-troubleshooting-techniques

Electronics-Tutorials. (n.d.). *Basic Electronic Circuits*. Retrieved from Electronics-Tutorials: https://www.electronics-tutorials.ws/blog/basic-electronic-circuits.html

Electronics-Tutorials. (n.d.). *Fault Finding in Electronic Circuits*. Retrieved from Electronics-Tutorials: https://www.electronics-tutorials.ws/blog/fault-finding-electronic-circuits.html

Gibilisco, S. (2016, February 4). *How to Read Circuit Diagrams for Beginners*. Retrieved from www.Instructables.com: https://www.instructables.com/How-to-Read-Circuit-Diagrams-for-Beginners/

Hill, P. H. (2024, September 21). *How to Read a Schematic*. Retrieved from www.All About Circuits.com: https://www.allaboutcircuits.com/textbook/direct-current/chpt-7/how-to-read-a-schematic/

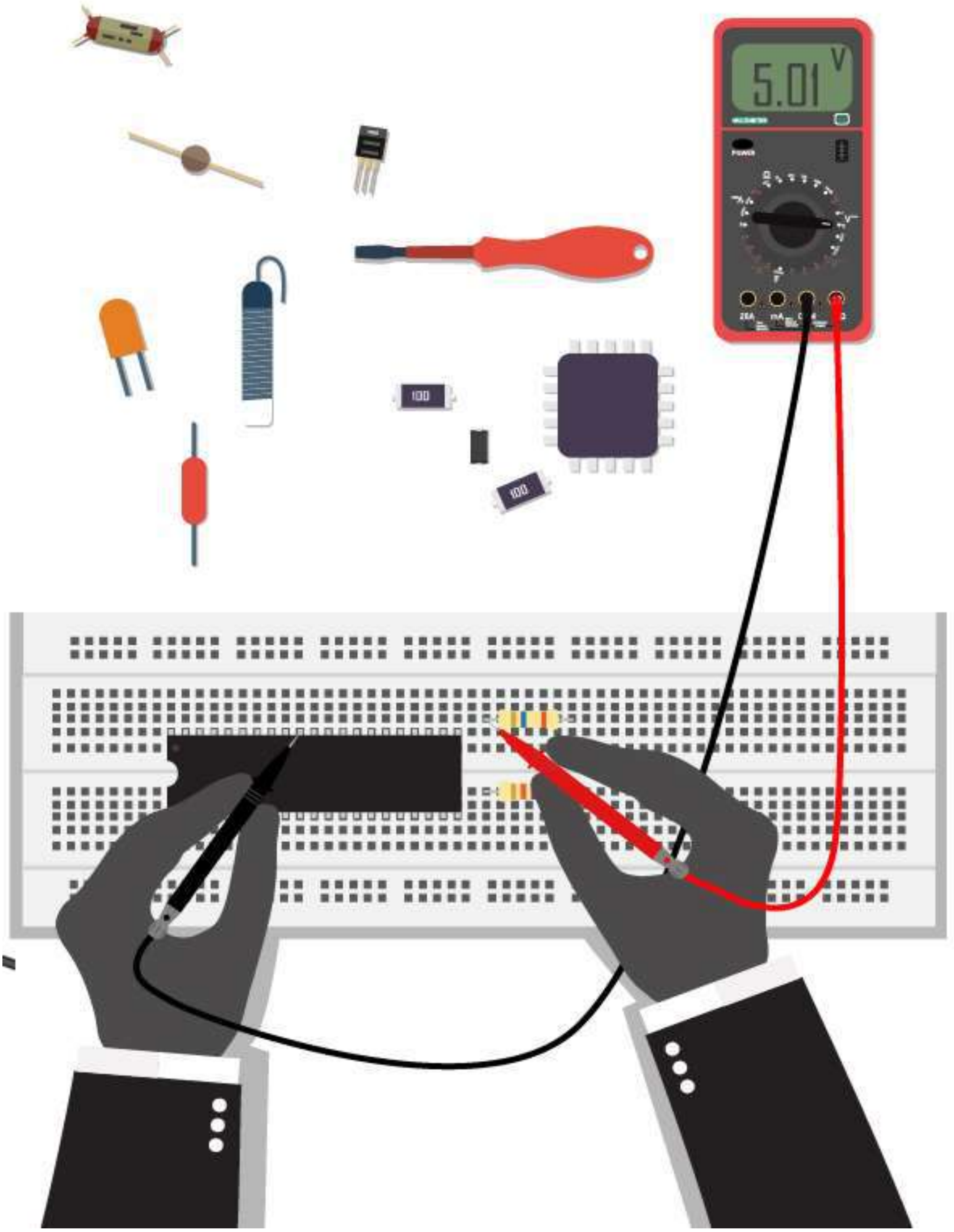
Hill, P. H. (2024, September 21). *How to Read a Schematic*. Retrieved from www.All About Circuits.com: https://www.allaboutcircuits.com/textbook/direct-current/chpt-7/how-to-read-a-schematic/

Instructables. (n.d.). *Simple Electronic Circuits for Beginners*. Retrieved from www.Instructables.com: https://www.instructables.com/Simple-Electronic-Circuits-for-Beginners/

McComb, C. S. (2019, March 3). *How to Read and Understand Circuit Diagrams*. Retrieved from Circuit Digest: https://circuitdigest.com/article/how-to-read-and-understand-circuit-diagram

Monk, P. S. (2016, June 15). *Understanding Circuit Diagrams*. Retrieved from Electronics-Tutorials: https://www.electronics-tutorials.ws/schematic/schematic_1.html

END


5.01
V

Indicative contents
2.1 Selection of circuit components **2.2 Identification of tools, materials and equipment**

Key Competencies for Learning Outcome 2: Build electronic circuit

Knowledge	Skills	Attitudes
• Identification of components, tools, materials and equipment • Description of circuit components • Description of soldering techniques • Description of component terminals	• Selecting circuit components. • Using tools, materials and equipment. • Mounting electronic components on breadboard • Soldering electronic components on PCB	• Having Precision • Being Attentive • Having self-confident • Having accountability • Respecting time • Being patient • Having self-motivation • Being organized

Duration: 30 hrs

Learning outcome 2 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Select correctly components, tools, materials and equipment according to the circuit requirements.
2. Mount properly electronic circuit components on breadboard for prototyping in line with circuit diagram.
3. Solder correctly electronic components on PCB in respect with soldering techniques.

Resources

Equipment	Tools	Materials
• Power supply unit • Function generator • Oscilloscope • Digital multimeter	• Cutting tools • Soldering iron • Measurement tools	• Connectors • Soldering tin • Soldering paste • Cleaning solvents

• Soldering station	• Cleaning tools Disordering pump • ESD tool kits	• Wires

Indicative content 2.1: Selection of Circuit Components

Duration: 3 hrs

Theoretical Activity 2.1.1: Description of circuit component

Tasks:

1: Answer the following questions:

i. What do you understand by the term?
   a. Analog components
   b. Digital components

ii. Give the different between of Analog components and Digital components

2: Provide the answers for the asked questions and write them on flipchart/papers.

3: Present the findings/answers to the whole class.

4: For more clarification, read the key readings 2.1.1.

5: In addition, ask questions where necessary.

Key readings 2.1.1.: Description of circuit component

1. Analog components:

Analog components are fundamental in electronic circuits, especially in creating analog circuits where continuous signals are involved. Analog components include:

- ✓ **Resistors:** These components limit the flow of current in a circuit. They're commonly used to control voltage and current levels.
- ✓ **Capacitors:** These store and release electrical energy in the form of an electric field. They are used for filtering, smoothing power supplies, and timing circuits.
- ✓ **Inductors:** These store energies in a magnetic field when current flows through them. They're used in filters, oscillators, and power supply applications.
- ✓ **Diodes:** These allow current to flow in one direction and block it in the opposite direction. They're used in rectification, signal demodulation, and voltage regulation.
- ✓ **Transistors:** These are the building blocks of modern electronics, used for amplification, switching, and signal processing.
- ✓ **Operational Amplifiers (Op-Amps):** These are versatile, high-gain amplifiers used in a wide range of applications, such as signal conditioning, filtering, and mathematical operations.
- ✓ **Sensors:** These components convert physical quantities (like temperature, light, pressure, etc.) into electrical signals.

When designing a circuit, it's common to use a combination of these components to achieve specific functionality or behaviors. The arrangement and connection of these components in a circuit diagram determine how the circuit operates.

2.Digital components:

A circuit diagram typically involves various digital components that facilitate the flow and manipulation of digital signals these includes:

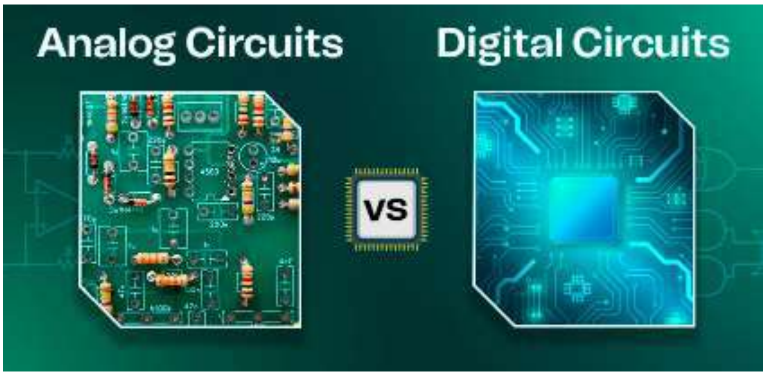
- ✓ **Logic Gates**: Basic building blocks of digital circuits. Examples include AND, OR, NOT gates, etc., which perform logical operations on input signals.
- ✓ **Flip-Flops**: These are memory elements used to store binary information. They come in various types like D flip-flops, JK flip-flops, etc.
- ✓ **Registers:** They store data temporarily during processing and are composed of flip-flops.
- ✓ **Multiplexers and Demultiplexers**: Multiplexers select one of many input lines and route it to a single output, while Demultiplexers perform the reverse.
- ✓ **Adders and Subtractors**: These perform arithmetic operations in digital circuits.
- ✓ **Counters:** Used to count pulses or events and can be designed to increment or decrement.
- ✓ **Encoders and Decoders:** Encoders convert data from one format to another, while decoders perform the reverse operation.
- ✓ **Integrated Circuits (ICs):** Various specialized ICs like microcontrollers, microprocessors, memory chips, etc., are used in digital circuit designs.
- ✓ **Transistors:** They are fundamental components used in digital circuits for amplification or switching purposes.
- ✓ **Diodes:** While primarily used in analog circuits, diodes can also have specific digital applications in logic gates and signal modulation.

These components are combined and interconnected in different ways to create circuits that perform specific functions, ranging from simple tasks to complex operations in digital devices and systems

The difference between of Analog components and Digital components

When you are designing a PCB (Printed Circuit Board) the confusion of analog vs digital circuits becomes so obvious. PCB is a crucial component for each electronic system, especially in manufacturing and other industrial domains.

The main difference is in signal processing: analog circuits deal with analog signals which are continuously varying smoothly while the digital circuits deal with discrete signals which are in the form of 0’s and 1’s only.



The difference between analog and digital circuits is fundamental in electronics, with each having its own advantages. Knowing the differences of analog vs digital circuits is crucial if you are choosing tech stack for certain operations and devising efficient electronic systems.

Factors	Analog Circuits	Digital Circuits
Signal Representation	Information is represented using continuous signals	Information is passed in different binary signals.
Precision and Fidelity	Help to provide high precision in signal representation, which makes them ideal for audio and radio frequency (RF) applications.	Robust and consistent in terms of signal representation, making them an ideal fit for data processing and storage purposes.
Noise and Interference	More prone to noise and signal latency over distance	Offer higher Db of noise cancellation and are fit for reliable performance in varied environments.
Design Complexity	More meticulous in design and particularly in component selection, making it complex to design from scratch.	Simpler with standardized components and logic gates.
Integration and Scalability	Challenging to scale to maintain signal integrity across larger systems	Offer ease as they function on binary systems.

Points to Remember

- **Analog Components:**

Analog components are electronic components that deal with continuous signals, where the signal can vary smoothly over a range of values. These components process signals that represent physical quantities, such as voltage or current, which can take any value within a specified range. Examples of analog components include:

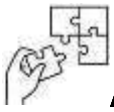
- ✓ Resistors: Control the flow of electric current.
- ✓ Capacitors: Store and release electrical energy.
- ✓ Inductors: Store energy in a magnetic field when current flows through them.
- ✓ Operational Amplifiers (Op-Amps): Amplify voltage signals.
- ✓ Transistors: Used for amplifying or switching analog signals.

- **Digital components**

Digital components are electronic components that work with discrete signals, typically representing binary values (0s and 1s).

- ✓ Logic Gates (AND, OR, NOT, etc.): Perform basic binary operations.
- ✓ Flip-Flops: Store binary data as 0 or 1.
- ✓ Counters: Count pulses or events in binary.
- ✓ Microcontrollers: Small computers on a chip that execute programmed instructions.
- ✓ Memory Chips (RAM, ROM): Store digital data.

- The main difference between analog and digital components in building electronic circuit is in signal processing: analog circuits deal with analog signals which are continuously varying smoothly while the digital circuits deal with discrete signals which are in the form of 0’s and 1’s only.



Application of learning 2.1

At KIGALI Electronic Innovations Group**,** you're assigned to Draw circuit diagram that present DC power supply on the physical sheet before it is made and implemented remember to set the names of the components and other element so that your drawing is understandable to the people who will implement it after show the analog and digital components used.

Indicative content 2.2: Identification of Tools, Materials and Equipment

Duration: 25 hrs

Theoretical Activity 2.2.1: Description of Tools, materials and Equipment used to build electronic circuit

Tasks:

1: You are asked to answer the following questions:

i. Define the following terms:
   a. Tools
   b. Materials
   c. equipment

ii. List different examples of tools, materials and equipment that can be used to build electronic circuit.

2: Provide the answers for the asked questions and write them on flipchart/papers.

3: Present the findings/answers to the whole class.

4: For more clarification, read the key readings 2.2.1.

5: In addition, ask questions where necessary.

Key readings 2.2.1.: Description of Tools, materials and Equipment used to build electronic circuit

1. Tools

Tools are used to work with materials to shape, size, bend, straighten, drill holes

Examples of tools

✓ **Cutting Tools:**
- **Utility Knife:** For general cutting tasks.
- **Scissors:** Useful for cutting wires, tape, etc.
- **Wire Cutters:** Specifically, for cutting wires cleanly.
- **Pliers:** Helpful for gripping and cutting.

✓ **Soldering Station Kit:**
- **Soldering Iron:** To melt solder for joining electrical components.
- **Solder:** For creating electrical connections.
- **Soldering Stand:** To hold the hot iron when not in use.
- **Solder Wick/Sucker**: For removing excess solder.

- ✓ **Testing Tools:**
  - **Multimeter**: For measuring voltage, current, and resistance. 59
  - **Voltage Tester:** To check if a circuit is live.
  - **Circuit Tester/Probe:** To check continuity or trace circuits.
- ✓ **Cleaning Tools:**
  - **Brushes:** Soft brushes for delicate cleaning tasks.
  - **Compressed Air:** For blowing away dust and debris.
  - **Isopropyl Alcohol:** For cleaning electronic components.
- ✓ **ESD Tool Kits (Electrostatic Discharge):**
  - **Antistatic Wrist Strap:** To prevent static discharge damaging sensitive electronics.
  - **Antistatic Mat:** Provides a safe surface for working on electronics.
  - **ESD-Safe Tweezers:** To handle delicate components

2. Materials

Materials are the raw products you make something with which could be just about anything such as wood, metals, plants, liquids, chemicals etc.

Examples of materials

- ✓ **Connectors**:
  - **Wire Connectors:** Terminal blocks, screw terminals, crimp connectors, wire nuts, etc.
  - **Board Connectors:** Pin headers, female headers, molex connectors, etc.
  - **RF Connectors:** SMA, BNC, N-type connectors for radio frequency applications.
  - **Audio/Video Connectors:** HDMI, RCA, 3.5mm audio jacks, etc.
- ✓ **Soldering Materials:**
  - **Soldering Iron:** A tool to heat and melt solder.
  - **Solder Wire:** Lead-based or lead-free solder for joining components.
  - **Soldering Flux:** Used to clean and prepare surfaces for soldering.
  - **Soldering Station:** A more advanced setup with temperature control and additional features.
  - **Disordering Tools:** Disordering pump, wick, or vacuum for removing solder.
- ✓ **Cleaning Materials:**
  - **Isopropyl Alcohol:** Used for cleaning flux residues after soldering.
  - **Lint-free Cloths or Swabs:** For applying cleaning solutions and wiping surfaces.
  - **Contact Cleaner:** Helps clean electrical contacts and connectors.
  - **Brushes:** Small brushes for removing debris or dust from components

3. Equipment

Equipment encompasses a broader range of tools and machinery necessary for a particular purpose

Examples of equipment

- ✓ **Power Supply Unit:** Supplies electrical power to the circuit. It provides different voltage and current outputs to suit the requirements of the components being used.
- ✓ **Function Generator:** Produces various types of waveforms (like sine, square, triangle waves) at different frequencies. It's useful for testing and simulating different signal inputs to a circuit
- ✓ **Oscilloscope:** Measures and displays voltage signals as they vary over time. It helps visualize and analyse the behaviour of electrical signals in the circuit.
- ✓ **Multimeter:** Measures different electrical properties such as voltage, current, and resistance. It's a versatile tool for troubleshooting and measuring various parameters within a circuit.
- ✓ **Prototyping on Breadboard:** A breadboard is a tool for building temporary prototypes of electronic circuits. Components like resistors, capacitors, integrated circuits, and wires are inserted into the breadboard's interconnected holes, allowing for easy experimentation and modifications without soldering.

These tools are essential for designing, testing, and troubleshooting electronic circuits during the prototyping phase before moving to a more permanent setup like soldering components onto a PCB (printed circuit board).

Theoretical Activity 2.2.2: Description of component terminals and internal connection of breadboard

Tasks:

1: You are asked to answer the following questions:

i. What does component terminals mean?
ii. Discuss on internal connection of breadboard and why is it important when you need to build electronic circuit.

2: Provide the answers for the asked questions and write them on flipchart/papers.
3: Present the findings/answers to the whole class.
4: For more clarification, read the key readings 2.2.2.
5: In addition, ask questions where necessary.

Key readings 2.2.2.: Description of component terminals and internal connection of breadboard

A breadboard is a tool used for prototyping electronic circuits without the need for soldering. Here's a brief description of its components, terminals, and internal connections

Components of a Breadboard

Component terminals refer to the physical points or connectors on an electrical or electronic component where external connections are made to support the building of electronic circuits.

1. **Terminals:**
   - **Power Rails:** Usually located along the top and bottom edges, these are typically marked with red (positive) and blue or black (negative) lines. They provide a convenient way to distribute power to the circuit.
2. **Terminal Strips:** The main area of the breadboard consists of several rows and columns of holes. Each row typically has a series of interconnected holes that allow components and wires to be inserted and connected.

2. **Connection Points:**
   - **Horizontal Connections:** In the terminal strips, the holes in the same horizontal row are electrically connected. This allows components to share connections easily.
   - **Vertical Connections:** The vertical columns of holes (often used for power and ground) are typically separated into two sections, with a gap in the middle. This is to prevent unintentional short circuits.

Internal Connections

The internal connection of a breadboard refers to how the metal strips inside the breadboard connect the holes (also called terminals) in rows or columns. These connections allow you to build circuits by inserting electronic components, like resistors, LEDs, and wires, into the holes.

Here's a general layout of the internal connections in a typical breadboard:

1. **Interconnected Rows:**
   - Each horizontal row of holes is connected internally. For most breadboards, this typically extends across 5 holes (e.g., the first five holes in a row are interconnected).
2. **Power Rails:**

- The power rails are connected to one another along their length, providing a continuous path for power. They may have connection points for external power sources, such as battery clips.

3. **Gap in the Middle:**
   - The gap between the vertical power connections prevents components from connecting unintentionally across the power and ground lines.
4. **Vertical Columns:**
   - On some breadboards, the vertical columns (usually for power) may be connected to allow multiple rows to access the same power source

Theoretical Activity 2.2.3: Description of mounting components on the breadboard

Tasks:

1: You are asked to answer the following questions:

i. Define the following term:
   a. Mounting component.
   b. Soldering electronic component.

ii. What are soldering techniques you must follow when you need to build electronic circuit?

2: Provide the answers for the asked questions and write them on flipchart/papers.

3: Present the findings/answers to the whole class.

4: For more clarification, read the key readings 2.2.3.

5: In addition, ask questions where necessary.

Key readings 2.2.3: Description of mounting components on the breadboard

1. Overview of Breadboard Structure:

A breadboard is designed to facilitate the quick assembly of electronic circuits without soldering. It consists of a grid of holes connected by internal metal strips, which allow for various configurations and connections.

✓ **Component Placement:** refers to the process of placing electronic components, such as resistors, capacitors, and integrated circuits, onto a circuit board (either a breadboard, PCB, or any other surface).

- **Orientation:** When mounting components, ensure they are oriented correctly, especially polarized components like electrolytic capacitors, diodes, and ICs.
- **Stable Insertion:** Push the leads of components into the holes firmly to ensure a good connection. Components should be inserted straight to maintain stability.

✓ **Terminal Strips:**

- The terminal strips, typically organized into rows, are where most components are mounted. Each row generally accommodates several holes (often five) that are connected internally.
- **Using Terminal Strips:** Components like resistors and transistors can be mounted in these strips, allowing for easy connections among them.

✓ **Integrated Circuits (ICs):**

- ICs should be placed so that they straddle the central gap of the breadboard. This design prevents short circuits between adjacent pins and provides easy access to each pin for wiring.
- **Pin Mapping:** Always check the datasheet of the IC to ensure correct pin mapping when making connections.

✓ **Power and Ground Connections:**

- Components that require power should be connected to the designated power rails. It's crucial to use the correct voltage to avoid damaging components.
- **Color Coding:** Utilize red wires for power connections and black or blue for ground connections to help keep the circuit organized and reduce errors.

✓ **Using Jumper Wires:**

- Jumper wires are essential for connecting different components and power rails. They can be inserted into any of the holes on the breadboard.
- **Wire Lengths:** Use appropriate lengths to avoid overcrowding and to maintain a tidy layout.

✓ **Organization and Layout:**

- **Space Management:** Leave sufficient space between components to allow for easy access and modification.
- **Labeling:** If the circuit is complex, consider labeling connections or using a schematic diagram to track the layout.

✓ **Checking Connections:**

- After all components are mounted, visually inspect the breadboard for loose connections or potential shorts. This helps prevent issues when powering the circuit.
- **Testing:** Use a multimeter to verify connections and check for continuity before applying power to the circuit.

✓ **Common Practices:**

- Avoid excessive force when inserting components to prevent damaging the breadboard.

- When dealing with multiple connections, use different colors of jumper wires to distinguish between power, ground, and signal connections.

✓ **Advantages of Bread boarding:**

- **Rapid Prototyping:** The breadboard allows for quick testing of circuit designs, enabling fast iteration and experimentation.
- **Accessibility:** Components can be easily added, removed, or replaced without permanent changes, making it ideal for educational purposes and hobby projects.

2. Soldering

It is the process of joining electronic components to a circuit board by melting a metal alloy (called solder) around the component's leads and the metal pads on the board?

✓ **Steps involved in Soldering electronic components**:

- Preparation
- Clean PCB
- Component Placement
- Soldering Technique
- Cooling and Inspection
- Testing

✓ **Soldering techniques, you must follow when you need to build electronic circuit.**

- Heat the soldering iron and apply a small amount of solder to its tip to aid heat transfer.
- Heat the component lead and the copper pad on the PCB simultaneously for a few seconds.
- Apply solder to the junction of the lead and pad until it melts and forms a smooth fillet. Avoid excessive solder.

Practical Activity 2.2.4: Implementing electronic circuit

Task:

1: You are requested to build a 5V DC power supply that can be used to power small electronic devices. The power supply will convert a higher DC voltage (e.g., 12V) into a stable 5V output.
2: Read the key readings 2.2.4 about build a 5V DC power supply that can be used to power small electronic devices. By following the steps from key reading, perform the given task
4: Present the work to the whole class.
5: In addition, ask questions where necessary

Key readings 2.2.4: Implementing electronic circuit

1. Requirements needed to build and implement a 5vdc power supply

1.1. Circuit Design and Planning

- **Objective**: Design and build a 5V DC power supply using a voltage regulator.
- **Components Needed**:

  - ✓ 1x LM7805 Voltage Regulator (5V)
  - ✓ 1x 12V DC Input Source (e.g., a wall adapter)
  - ✓ 2x Capacitors (0.1µF and 1µF)
  - ✓ 1x Diode (1N4007)
  - ✓ 1x LED (optional, for power indication)
  - ✓ 1x Resistor (330Ω, for the LED)
  - ✓ 1x PCB or Breadboard
  - ✓ Wires for connections

1.2. Bread boarding

1.2.1. Assemble the Circuit on a Breadboard:

- ✓ Connect the **input** (12V) to the **input pin** of the LM7805.
- ✓ Place the **0.1µF capacitor** between the input pin and ground (GND).
- ✓ Place the **1µF capacitor** between the output pin and GND.
- ✓ Connect the **output pin** of the LM7805 to the **+5V output line**.
- ✓ If using an LED for indication, connect it to the output line through the 330Ω resistor and then to GND.
- ✓ Insert the **diode** in series with the input to protect the circuit from reverse polarity.

1.3. Test the Circuit:

- ✓ Power the circuit by connecting the 12V input.
- ✓ Use a multimeter to check the voltage at the output pin of the LM7805. It should read 5V.
- ✓ Observe the LED; it should light up if connected, indicating the circuit is powered.

2. Mounting Components on PCB

2.1. Place Components:

- ✓ Position the LM7805, capacitors, diode, and LED on the PCB as per the circuit diagram.
- ✓ Insert the component leads through the holes on the PCB.

2.2. Soldering Components

✓ **Heat Soldering Iron**:
Ensure the soldering iron is at the appropriate temperature for the solder you're using.

✓ **Solder Joints**:
Solder each lead to the corresponding pad on the PCB, ensuring good electrical contact and a clean, shiny solder joint.
Trim any excess leads after soldering.

✓ **Inspect and Clean**:
Examine each solder joint for cold solder joints or bridges. Clean up any flux residue if necessary.

2.3. Powering and Testing the Circuit

✓ **Connect Power**:
Attach the 12V DC input source to the circuit.

✓ **Test Functionality**:
Measure the output voltage using a multimeter; it should be stable at 5V.
Check that the LED (if used) is lit, indicating the circuit is powered correctly.

Points to Remember

- **Tools:** are Hand-held devices or instruments used to assemble, modify, or repair electronic circuits. Examples of tools include:
  - ✓ Soldering Iron: To melt solder for joining electrical components.
  - ✓ Soldering Stand: To hold the hot iron when not in use.
  - ✓ Solder Wick/Sucker: For removing excess solder
- **Materials:** are Basic components and supplies used to construct the circuit and make electrical connections. Examples of materials include:
  - o **Connectors:**
  - ✓ Wire Connectors

- ✓ Board Connectors
- ✓ RF Connectors Audio/Video Connectors
  - o **Soldering Materials**
- ✓ Soldering Iron
- ✓ Solder Wire
- ✓ Soldering Flux
- ✓ Soldering Station

- **Equipment:** Larger or more complex devices used to test, measure, or support the building of electronic circuits. Examples of equipment include:
  - ✓ Power Supply Unit
  - ✓ Function Generator
  - ✓ Oscilloscope
  - ✓ Multimeter

- **Component terminals** refer to the physical points or connectors on an electrical or electronic component where external connections are made to support the building of electronic circuits.
- **The internal connection of a breadboard** refers to how the metal strips inside the breadboard connect the holes (also called terminals) in rows or columns. These connections allow you to build circuits by inserting electronic components, like resistors, LEDs, and wires, into the holes.
- **Component Placement** refers to the process of placing electronic components, such as resistors, capacitors, and integrated circuits, onto a circuit board (either a breadboard, PCB, or any other surface).
- **Soldering techniques, you must follow when you need to build electronic circuit.**
  - ✓ Heat the soldering iron and apply a small amount of solder to its tip to aid heat transfer.
  - ✓ Heat the component lead and the copper pad on the PCB simultaneously for a few seconds.
  - ✓ Apply solder to the junction of the lead and pad until it melts and forms a smooth fillet. Avoid excessive solder.

- **The following are requirements needed to build and implement a 5vdc power supply**
  - ✓ Circuit Design and Planning
  - ✓ Bread boarding
  - ✓ Test the Circuit**:**
  - ✓ Soldering Components
  - ✓ Inspect and Clean
  - ✓ Powering and Testing the Circuit
  - ✓ Test Functionality

Application of learning 2.2.

- MW Electronics Ltd., located in Kigali Tech Park, specializes in designing and implementing electronic circuits for various devices. The company has been tasked with upgrading a Radio receiver to include a more reliable 5V DC power supply. As a trainee at MW Electronics Ltd., you are asked to design and implement this power supply to ensure stable operation.

Learning outcome 2 end assessment

Written assessment

1. Answer the following question by **TRU**E or **FALSE**
   A. Analog components are electronic components that do not deal with continuous signals, where the signal can vary smoothly over a range of values.
   B. Digital components are electronic components that work with discrete signals, typically representing binary values (0s and 1s).
2. By using a table, Classify the following components as analog or digital components used to build electronic circuit:
   Resistors**,** Logic Gates (AND, OR, NOT, etc.), Capacitors, Microcontrollers, Inductors, Operational Amplifiers (Op-Amps), Transistors, Flip-Flops Counters,
3. Choose the correct answer:
   Here's a general layout of the internal connections in a typical breadboard EXCEPT
   A. Rows
   B. Columns
   C. Nodes
   D. Power Rails
4. List Steps required to mount electronic components on the board?
5. Match the column **A** to its corresponding type to the column **B**.

Column **A**	Column **B**
1. Power Supply Unit	**A.** Cleaning Tools
2. Wire Connectors	**B.** Cutting Tools
3. Brushes	**C.** Equipment
4. Wire Cutters	**D.** Material

Practical assessment

As a junior electronics engineer at Circuit Wave Technologies**,** you are tasked with designing and testing a bridge rectifier circuit as part of the power supply unit for a new desktop computer. The bridge rectifier is crucial as it converts the AC (alternating current) input from the mains supply to a DC (direct current) output, which will power the desktop computer. Your goal is to design the bridge rectifier circuit, simulate its performance, and document the results for review by the senior engineering team.

References

Circuits, A. A. (n.d.). *How to Build a Simple Circuit*. Retrieved from All About Circuits: https://www.allaboutcircuits.com/projects/how-to-build-a-simple-circuit/

Circuits, A. A. (n.d.). *Troubleshooting Circuits: Basics and Testing*. Retrieved from All About Circuits: https://www.allaboutcircuits.com/technical-articles/troubleshooting-circuits-basics-and-testing/

Digest, C. (n.d.). *Basic Electronics Projects for Beginners*. Retrieved from www.Circuit Digest.com: https://circuitdigest.com/electronic-circuits

Digest, C. (n.d.). *Top 10 Basic Electronics Troubleshooting Techniques*. Retrieved from Circuit Digest: https://circuitdigest.com/article/top-10-basic-electronics-troubleshooting-techniques

Digest, C. (n.d.). *Top 10 Basic Electronics Troubleshooting Techniques*. Retrieved from www.Circuit Digest.com: https://circuitdigest.com/article/top-10-basic-electronics-troubleshooting-techniques

Electronics-Tutorials. (n.d.). *Basic Electronic Circuits*. Retrieved from Electronics-Tutorials: https://www.electronics-tutorials.ws/blog/basic-electronic-circuits.html

Electronics-Tutorials. (n.d.). *Fault Finding in Electronic Circuits*. Retrieved from Electronics-Tutorials: https://www.electronics-tutorials.ws/blog/fault-finding-electronic-circuits.html

Gibilisco, S. (2016, February 4). *How to Read Circuit Diagrams for Beginners*. Retrieved from www.Instructables.com: https://www.instructables.com/How-to-Read-Circuit-Diagrams-for-Beginners/

Hill, P. H. (2024, September 21). *How to Read a Schematic*. Retrieved from www.All About Circuits.com: https://www.allaboutcircuits.com/textbook/direct-current/chpt-7/how-to-read-a-schematic/

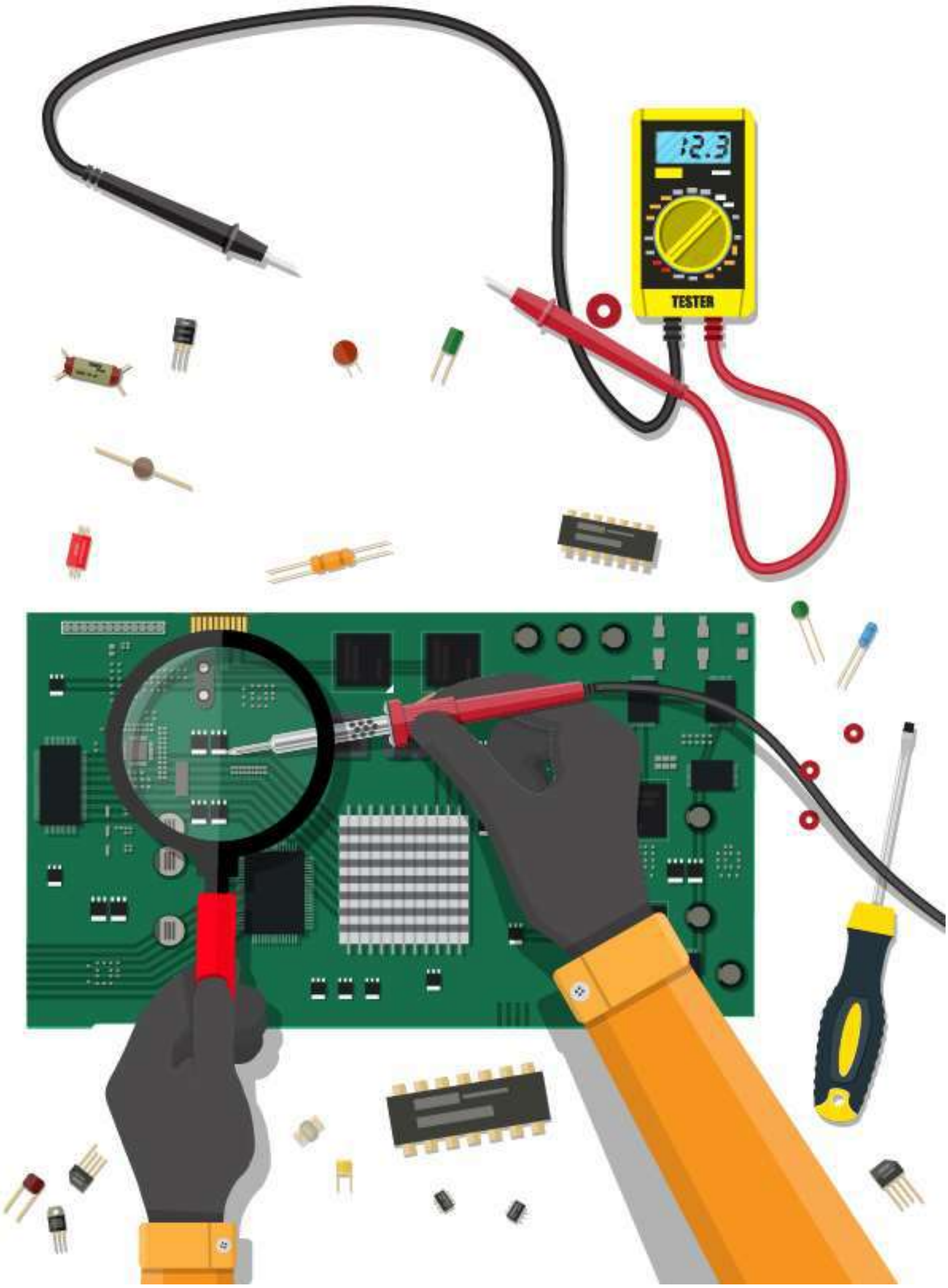
Hill, P. H. (2024, September 21). *How to Read a Schematic*. Retrieved from www.All About Circuits.com: https://www.allaboutcircuits.com/textbook/direct-current/chpt-7/how-to-read-a-schematic/

Instructables. (n.d.). *Simple Electronic Circuits for Beginners*. Retrieved from www.Instructables.com: https://www.instructables.com/Simple-Electronic-Circuits-for-Beginners/

McComb, C. S. (2019, March 3). *How to Read and Understand Circuit Diagrams*. Retrieved from Circuit Digest: https://circuitdigest.com/article/how-to-read-and-understand-circuit-diagram

Monk, P. S. (2016, June 15). *Understanding Circuit Diagrams*. Retrieved from Electronics-Tutorials: https://www.electronics-tutorials.ws/schematic/schematic_1.html

Learning Outcome 3: Troubleshoot Electronic Circuit



Indicative contents
3.1 Description of circuit faults **3.2 Calibration of testing equipment** **3.3 Application of safety considerations for repairing electronic circuit** **3.4 Application of testing techniques** **3.5 Application of circuit troubleshooting methods** **3.6 Elaboration of electronic circuit implementation report**

Key Competencies for Learning Outcome 3: Troubleshoot Electronic Circuit

Knowledge	Skills	Attitudes
• Description of circuit fault • Identification of variating of testing equipment • Identification of testing techniques • Identification of circuit troubleshooting methods • Description of electronic circuit implementation report	• Troubleshooting circuit fault • Calibrating of testing equipment • Applying safety consideration for repairing electronic circuit • Applying testing techniques • Applying of troubleshooting methods • Elaborating electronic circuit implementation report	• Having Precision • Being Attentive • Having self-confident • Having accountability • Respecting time • Being patient • Having self-motivation • Being organized

Duration: 20 hrs

Learning outcome 3 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Select correctly testing tools and equipment according to the circuit diagram functionality
2. Calibrate appropriately testing equipment according to the components ratings.
3. Troubleshoot systematically electronic circuit based on desired output

<table>
<tr><td colspan="3">4.Elaborate correctly report based on work done</td></tr>
<tr><td colspan="3">Resources</td></tr>
<tr><th>Equipment</th><th>Tools</th><th>Materials</th></tr>
<tr><td>• Oscilloscope
• Digital Multimeter
• Power supply unit
• Function Generator</td><td>• Circuit tester
• Soldering iron
• Soldering iron
• Disordering pump
• Soldering iron stand</td><td>• Probe wires
• Soldering tin
• Soldering flux paste and power extension</td></tr>
</table>

Indicative content 3.1: Description Of Circuit Faults

Duration: 4 hrs

Theoretical Activity 3.1.1: Description of circuit fault, their causes and their signs

Tasks:

1: Answer the following questions:

i. What does circuit fault mean?

ii. List common circuit fault, their causes and their signs.

2: Provide the answers for the asked questions and write them on flipchart/papers.

3: Present the findings/answers to the whole class.

4: For more clarification, read the key readings 3.1.1.

5: In addition, ask questions where necessary.

Key readings 3.1.1.: Description of circuit fault, their causes and their signs

1. Definition of Circuit Faults

Circuit faults refer to any undesired or abnormal conditions that occur within an electrical circuit, leading to a disruption or failure in its normal operation.

3. **Common of Circuit Faults**

✓ **Short Circuit:** This occurs when a low-resistance path is created accidentally between two points in a circuit, causing excessive current flow. It often leads to overheating, damage, or even fire if not addressed promptly.

✓ **Open Circuit:** In this situation, a break or interruption occurs in the circuit, preventing the flow of current. It can be due to a disconnected wire, a broken component, or a faulty connection.

✓ **Ground Fault:** A ground fault happens when an unintended path to ground is created, allowing current to flow where it shouldn't. It can occur due to damaged insulation, faulty wiring, or equipment malfunctions.

✓ **Mechanical Fault:** This encompasses a broad range of issues, including physical damage to components, improper connections, loose wires, or malfunctioning parts within the circuit. Mechanical faults can lead to various problems like intermittent connections or inconsistent performance.

4. **Common causes of circuit faults**

- ✓ **Heat:** Excessive heat can lead to component degradation, melting, or even fires. Overheating often occurs due to high current, poor ventilation, or faulty components.
- ✓ **Moisture:** Water or moisture can cause short circuits, corrosion, and damage to electrical connections, leading to malfunction or failure of the circuit
- ✓ **Dirt and Contaminants:** Dust, debris, or other contaminants can accumulate on circuitry, causing electrical leakage, short circuits, or interference, disrupting the circuit's performance.
- ✓ **Abnormal or Excessive Movement:** Components or connections subjected to continuous vibration, shaking, or movement may loosen or break, disrupting the circuit's integrity.
- ✓ **Poor Installation:** Incorrect wiring, improper connections, or using components outside their specified parameters during installation can lead to circuit faults.
- ✓ **Manufacturing defects:** Faulty components or poor quality control during the manufacturing process can introduce inherent weaknesses or faults in the circuit

4. Common signs of Circuit Faults

4.1 Signs of Short Circuits:

- ✓ **Frequent Circuit Breaker Tripping:** If a circuit breaker frequently trips, it might indicate a short circuit.
- ✓ **Burning Smell:** A burning or smoky smell from outlets or appliances could suggest a short circuit.
- ✓ **Sparks or Arcs:** Visible sparks or arcs when plugging in or using an appliance can be a sign of a short circuit.

4.2 Signs of Ground Faults:

- ✓ **Continual Circuit Breaker Tripping:** Similar to short circuits, ground faults can trip the circuit breaker.
- ✓ **Electric Shocks:** Mild shocks when touching appliances or outlets can indicate a ground fault.
- ✓ **Burning Odor:** A burning smell without visible smoke might signal a ground fault

4.3 Signs of Mechanical Issues:

- **Unusual Noises:** Clanking, grinding, or squealing sounds from machinery or appliances can indicate mechanical problems.
- **Reduced Performance:** Decreased efficiency, power, or functionality in a

machine or system can suggest mechanical issues.

- **Physical Damage:** Visible wear, tear, or damage to components could indicate mechanical problems.

4.4 Additional Considerations:

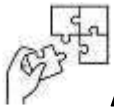
- **Overheating:** Whether electrical or mechanical, overheating of components is a common sign of trouble.
- **Flickering Lights:** While it can signal electrical issues, it may also indicate loose connections or mechanical vibrations affecting electrical contacts.

For all these issues, if you suspect a problem, it's best to have a professional electrician or technician inspect and resolve the problem to prevent safety hazards or further damage.

Points to Remember

- **Circuit fault refers** to any undesired or abnormal conditions that occur within an electrical circuit, leading to a disruption or failure in its normal operation.
- **Common circuit fault:**
  - ✓ Short Circuit
  - ✓ Open Circuit
  - ✓ Ground Fault
  - ✓ Mechanical Fault

- **Causes of circuit fault:**
  - ✓ Heat
  - ✓ Moisture
  - ✓ Dirt and Contaminants
  - ✓ Abnormal or Excessive Movement
  - ✓ Poor Installation
  - ✓ Manufacturing Defects
- **Signs of circuit fault:**
  - ✓ Signs of Short Circuits
  - ✓ Signs of Ground Faults
  - ✓ Signs of Mechanical Issues
  - ✓ Additional Considerations



Application of learning 3.1.

At Kigali Tech Solutions, you’re tasked with upgrading a smartphone’s charging circuit to include a stable 5V DC power supply. After upgrading it, you must check if there is no circuit fault presented in your electronic circuit then you confirm that all components are ready for the upgrade.

Indicative content 3.2: Calibration Of Testing Equipment

Duration: 4 hrs.

Practical Activity 3.2.1: Calibrating of testing equipment

Task:

1: You are requested to calibrate the testing equipment like Digital Multimeter, power supply, oscilloscope and check their functionality whether they are functioning normally.
2: Read the key readings 3.2.1 about calibrate the testing equipment like Digital Multimeter, power supply. By following the steps from key reading, perform the given task
4: Present the work to the whole class.
5: In addition, ask questions where necessary

Key readings 3.2.1: Calibrating testing equipment

1. Definition of calibration

Calibration refers to the process of adjusting and verifying the accuracy and precision of measuring instruments or devices.

Regular calibration is essential to maintain the accuracy of these tools. It's also a good practice to perform calibration after any repairs or if the equipment has undergone significant environmental changes (temperature, humidity, etc.).

2. Steps to calibrate testing equipment

Step 1:Preparation:

- ✓ Review equipment specifications.
- ✓ Inspect the equipment for damage.
- ✓ Warm up the equipment.

Step 2: Calibrate testing equipment (Digital Multimeter, Oscilloscope, Power Supply, Function generator)

Step 3: Functionality Check:

- ✓ Verify accuracy with known values.
- ✓ Test all modes and functions.
- ✓ Check safety and protection features.

Step 4:Documentation:

- ✓ Record calibration results.
- ✓ Label the equipment with calibration details.

Step 5: Set Recalibration Schedule:

- ✓ Establish regular recalibration intervals.

Step 6:Final Inspection and Storage:

- ✓ Perform a final inspection.
- ✓ Store the equipment properly.

3. Calibration of testing equipment

3.1. Calibrating Digital Multimeter (DMM)

- ✓ Check the multimeter against a known voltage source. You can use a voltage reference source or a calibrated voltage standard.
- ✓ Verify accuracy at various measurement ranges (voltage, current, resistance) and adjust if necessary using calibration adjustments provided by the manufacturer.

3.2. Calibrating Oscilloscope

- ✓ Calibrate the oscilloscope's vertical and horizontal scales using a signal generator with known frequency and amplitude.
- ✓ Adjust and verify the accuracy of voltage measurements at various frequencies.
- ✓ Confirm triggering accuracy by comparing the displayed waveform with the known input.

3.3. Calibrating Power Supply

- ✓ Use a calibrated multimeter to measure the output voltage and current accuracy against the set values.

3.4. Calibrating Function Generator

- ✓ Use an oscilloscope or another calibrated instrument to verify the frequency and amplitude output of the function generator.
- ✓ Check for waveform accuracy (sine, square, triangle, etc.) against known standards or references.

Note: For all equipment

- ✓ Follow manufacturer-provided procedures for calibration if available.
- ✓ Keep a record of calibration dates, results, and adjustments made.
- ✓ If unsure or uncomfortable with calibration, consider hiring a professional calibration service.

Why Calibration of Testing Equipment is Important

- ✓ **Accuracy**: Ensures measurements are close to true values, preventing errors.
- ✓ **Compliance**: Meets industry standards and regulatory requirements.
- ✓ **Reliability**: Builds confidence in measurement results and prevents faulty data.
- ✓ **Performance**: Maintains equipment efficiency and detects issues early.
- ✓ **Cost Savings**: Reduces waste and prevents expensive rework or repairs.
- ✓ **Safety**: Ensures accurate measurements for critical applications, enhancing safety.
- ✓ **Documentation**: Provides a record of equipment performance and adjustments, ensuring traceability.
- ✓ **Improvement**: Establishes benchmarks for accurate measurements and enhances measurement techniques.

Regular calibration is essential to maintain the accuracy of these tools. It's also a good practice to perform calibration after any repairs or if the equipment has undergone significant environmental changes (temperature, humidity, etc.)

Points to Remember

- **Calibration** refers to the process of adjusting and verifying the accuracy and precision of measuring instruments or devices.
- Here's a general guideline for calibrating the equipment below:
  - ✓ **Digital Multimeter (DMM):**

    • Check the multimeter against a known voltage source. You can use a voltage reference source or a calibrated voltage standard.
  - ✓ **Oscilloscope:**

    • Calibrate the oscilloscope's vertical and horizontal scales using a signal generator with known frequency and amplitude.
  - ✓ **Power Supply:**

    • Use a calibrated multimeter to measure the output voltage and current accuracy against the set values.
  - ✓ **Function Generator:**

    • Use an oscilloscope or another calibrated instrument to verify the frequency and amplitude output of the function generator.

    For all equipment:

    • Follow manufacturer-provided procedures for calibration if available.

    • Keep a record of calibration dates, results, and adjustments made.

Application of learning 3.2.

At Kigali Tech Solutions, you are tasked with upgrading a smartphone’s charging circuit to include a stable 5V DC power supply. Before starting, you must calibrate the Digital Multimeter, Power Supply, and Oscilloscope to ensure accurate measurements. After calibration, you confirm that all equipment is ready for the upgrade.

Indicative content 3.3: Application of Safety Considerations for Repairing Electronic circuit

Duration: 3 hrs

Theoretical Activity 3.3.1: Description of safety consideration for repairing electronic circuit

Tasks:

1: Answer the following question:

i. What does safety measure mean?

ii. List and explain at least 5 key safety measures to consider when repairing electronic circuit

2: Provide the answers for the asked questions and write them on flipchart/papers.

3: Present the findings/answers to the whole class.

4: For more clarification, read the key readings 3.3.1.

5: In addition, ask questions where necessary.

Key readings 3.3.1: Description of safety consideration for repairing electronic circuit

Repairing electronic circuits involves several safety considerations to protect both the individual and the equipment.

- **Here are some key safety measures:**

- **Power Off and Discharge Capacitors:** Before beginning any repair work, ensure the device is powered off and unplugged from the electrical outlet. Capacitors can store dangerous charges even after power is disconnected, so discharge them using a resistor or specialized discharge tool.
- **Work Area Safety:** Have a clean, organized workspace with adequate lighting. Avoid clutter and ensure there are no liquids nearby that could cause damage if spilled.
- **Personal Safety Equipment:** Wear appropriate personal protective equipment (PPE) such as safety goggles, anti-static wrist straps, and gloves to protect against electrical shock and static discharge.
- **Use the Right Tools:** Use insulated tools designed for electronics repair. Tools should have insulated handles and be in good condition to prevent accidental electrical contact.

- **Identify and Understand Components:** Before handling the circuit, identify components and understand their functions. Refer to schematics or service manuals if available.

- **Anti-static Precautions:** Static electricity can damage sensitive electronic components. Work on an anti-static mat or surface and use an anti-static wrist strap to ground yourself and prevent static discharge

- **Isolate and Test:** Isolate the circuit you're working on to prevent accidental contact with other live circuits. Test the circuit after repair to ensure functionality before reconnecting power.
- **Avoid Heat Damage:** When soldering or using heat to repair components, be cautious not to apply excessive heat that could damage surrounding parts. Use a heat sink or heat-resistant materials if needed.
- **Ventilation:** Some repair work involves the use of chemicals or flux. Ensure proper ventilation in your workspace to avoid inhaling harmful fumes
- **Follow Manufacturer Guidelines:** Adhere to the manufacturer's guidelines and service manuals for specific safety instructions and precautions tailored to the equipment you're repairing.

Remember, if you're unsure or uncomfortable with any repair task, seek assistance from a professional technician or repair service to ensure safety and prevent further damage to the circuit.

Practical Activity 3.3.2: Applying safety for repairing electronic circuit

Task:

1: You are requested to apply safety consideration before repairing a cell phone charger which is not producing a needed output power to charge a cell phone.
2: Read the key readings 3.3.2 about calibrate the testing equipment like Digital Multimeter, power supply. By following the steps from key reading, perform the given task
3: Present the work to the whole class.
5: In addition, ask questions where necessary

Key readings 3.3.2: Applying safety consideration for repairing electronic circuit

1. Definitions

1.1.A cell phone charger

A cell phone charger is a device used to supply electrical power to your cell phone or smartphone, allowing its battery to recharge

2.Charging Cable

This is the cord that connects your phone to the power source. Common types include USB-C, Lightning (for iPhones), and micro-USB.

Power Adapter: This part plugs into a wall outlet and converts the electrical power from the outlet into a form that the phone can use. It usually has a USB port where you plug in the charging cable.

When repairing a cell phone charger that is not producing the necessary output power, several safety considerations are crucial to prevent injury or damage. Here are key safety measures to follow:

2.1. Unplug the Charger

Before attempting any repair, ensure the charger is completely disconnected from the power source. This prevents the risk of electric shock or short circuits while working on the device.

2.2. Discharge Any Capacitors

Chargers contain capacitors that can store electric charge even after the device is unplugged. Discharge these capacitors safely to avoid shocks. This can be done using a resistor or by waiting for the charge to dissipate over time.

2.3. Use Proper Tools

Use insulated tools designed for electrical work. This reduces the risk of accidental short circuits or shocks. Avoid using damaged or makeshift tools that could cause harm.

2.3. Avoid Water and Moisture

Ensure the work area is dry, and keep the charger away from any liquids.

Water and electricity are a dangerous combination, and even a small amount of moisture can cause a short circuit or electrocution.

2.4. Inspect for Physical Damage
Before opening the charger, inspect it for any obvious physical damage, such as frayed wires or burn marks. These can indicate more severe internal issues that might require professional repair. If the damage is significant, it might be safer to replace the charger entirely.

2.5. Understand the Circuit
Explanation: Have a good understanding of the charger's circuit and components before attempting repairs. Knowing what each part does and the typical voltages involved helps in diagnosing the issue safely and effectively.

2.6. Work in a Well-Lit Area
Proper lighting is essential to see what you're doing and avoid mistakes that could lead to accidents. A well-organized and clutter-free workspace also minimizes risks.

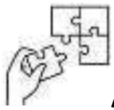
2.7. Test Safely After Repairs
After completing the repairs, test the charger carefully. Use a multimeter to check for correct output voltage before connecting it to a device. If possible, test the charger on a less valuable or expendable device first to ensure it is working correctly.

Points to Remember

- **Safety measures:** refer to the precautions and practices implemented to protect the technician and the equipment from potential hazards.
- **Repairing electronic circuits involves several safety considerations to protect both the individual and the equipment. Here are some key safety measures:**
  - ✓ Power Off and Discharge Capacitors
  - ✓ Work Area Safety
  - ✓ Personal Safety Equipment
  - ✓ Use the Right Tools
  - ✓ Identify and Understand Components

- When repairing a cell phone charger that is not producing the necessary output power, several safety considerations are crucial to prevent injury or damage. Here are key safety measures to follow:
  - ✓ Unplug the Charger
  - ✓ Discharge Any Capacitors

- ✓ Use Proper Tools
- ✓ Avoid Water and Moisture
- ✓ Inspect for Physical Damage
- ✓ Understand the Circuit
- ✓ Work in a Well-Lit Area
- ✓ Test Safely After Repairs



Application of learning 3.3

At TECH SAVY Innovations, you're assigned to repair a malfunctioning cell phone charger that isn't producing the needed output power. Before beginning the repair, you focus on ensuring the safety of the process by confirming that the charger is completely disconnected, capacitors are discharged, and the workspace is secure. After addressing these safety considerations, you proceed with the repair, using calibrated equipment to verify that the charger is functioning correctly before it’s returned to service.

Indicative content 3.4: Application of Testing Techniques

Duration: 3 hrs

Theoretical Activity 3.4.1: Description of testing techniques

Tasks:

1: Answer the following question:

i. What does testing techniques mean?

ii. List at least 5 testing techniques

2: Provide the answers for the asked questions and write them on flipchart/papers.

3: Present the findings/answers to the whole class.

4: For more clarification, read the key readings 3.4.1.

5: In addition, ask questions where necessary.

Key readings 3.4.1: Description of testing techniques

1. Definition

Testing techniques refer to the methods and procedures used to evaluate the functionality, performance, and reliability of electronic circuits or components

2. Types of testing techniques

Each of these testing techniques serves a specific purpose in ensuring the quality and functionality of electronic components or circuits.

2.1 Visual Inspection:

This is a basic technique involving human inspection to identify any visible defects, irregularities, or physical damage on the circuit board or components. It's often used in the initial stages of manufacturing or during maintenance to spot obvious issues like soldering defects, component misalignment, or physical damage.

2.2 In-Circuit Test (ICT):

ICT involves testing individual components on a completed circuit board while they're still mounted. It checks for proper operation, component values, and the functionality of the circuit without removing the components. It's efficient for high-volume production and can detect issues like incorrect components, shorts, opens, or incorrect values.

2.3 Flying Probe Test:

This technique uses automated equipment with moving probes to test circuits without the need for a dedicated test fixture. It's suitable for prototypes or low-volume production as it doesn't require creating custom fixtures. Flying probe tests help detect opens, shorts, and component values without physical contact damaging delicate components.

2.4 Automated Optical Inspection (AOI):

AOI uses cameras and image processing algorithms to inspect circuit boards for defects such as missing components, incorrect placements, soldering defects, or PCB traces. It's faster and more accurate than human inspection, making it valuable in high-volume production to detect minute defects that might not be visible to the naked eye

2.5 Functional Circuit Test*:*

This involves testing the entire circuit to ensure it meets its functional specifications. It evaluates the performance of the circuit under normal operating conditions to verify its functionality. It's particularly important for complex circuits and ensures that the final product works as intended.

Each technique has its strengths and limitations, and often, multiple methods are used in combination to thoroughly test electronic components or circuits at different stages of manufacturing or maintenance. This multi-layered approach helps to ensure higher quality and reliability in the final product.

Practical Activity 3.4.2: Appling of Testing Techniques

Task:

1: You are requested to apply testing techniques after repairing a cell phone charger which is not producing a needed output power to charge a cell phone.
2: Read the key readings 3.4.2 about applying of testing techniques after repairing a cell phone charger, perform the given task
4: Present the findings to the whole class.
5: In addition, ask questions where necessary
6: Do the task in the application of leaning 3.4

Key readings 3.4.2: Applying testing techniques

Testing techniques for electronic circuits are crucial to ensure that they function correctly, meet design specifications, and are free from defects.

✓ **Visual Inspection**

- **Objective**: Identify obvious physical defects or issues.
- **Techniques**:
  - **Component Inspection**: Check for damaged, misplaced, or incorrectly installed components.
  - **Soldering Inspection**: Look for poor solder joints, solder bridges, and cold solder joints.
  - **PCB Inspection**: Examine the printed circuit board for signs of damage or design flaws.

✓ **Basic Electrical Measurements**

- **Objective**: Verify basic electrical characteristics and functionality.
- **Techniques**:
  - **Voltage Measurement**: Use a multimeter to measure voltage at various points in the circuit.
  - **Current Measurement**: Measure current flowing through different parts of the circuit.
  - **Resistance Measurement**: Check the resistance of components and connections.

✓ **Functional Testing**

- **Objective**: Ensure that the circuit performs its intended functions.
- **Techniques**:
  - **Power-Up Testing**: Apply power to the circuit and observe its operation to ensure it behaves as expected.
  - **Signal Testing**: Apply known input signals and verify that the output matches expected results.

✓ **Oscilloscope Analysis**

- **Objective**: Examine waveforms and signal characteristics.
- **Techniques**:
  - **Signal Waveform Analysis**: Use an oscilloscope to observe and analyse waveforms, frequencies, and amplitudes.
  - **Timing Analysis**: Measure time-related characteristics such as pulse width, rise time, and fall time.

✓ **Signal Integrity Testing**

- **Objective**: Ensure the integrity of signals within the circuit.
- **Techniques**:
    - **Probe Testing**: Use high-frequency probes to check for signal distortions or degradation.
    - **Eye Diagrams**: Analyse eye diagrams to assess signal quality and integrity.

✓ **In-Circuit Testing (ICT)**

- **Objective**: Test the functionality of circuit components while they are installed on the PCB.
- **Techniques**:
    - **Functional Test Fixtures**: Use test fixtures to apply signals and measure outputs directly on the PCB.
    - **Boundary Scan**: Use boundary scan testing (JTAG) to test digital circuits and interconnections.

✓ **Automated Test Equipment (ATE)**

- **Objective**: Perform high-volume and repetitive testing efficiently.
- **Techniques**:
    - **Test Automation**: Use automated systems to perform electrical tests, functional tests, and measurements.
    - **Programmed Testing**: Execute pre-defined test sequences to verify circuit performance.

✓ **Thermal Testing**

- **Objective**: Assess the circuit's performance under varying temperature conditions.
- **Techniques**:
    - **Heat Dissipation Testing**: Measure how well the circuit dissipates heat during operation.
    - **Thermal Imaging**: Use thermal cameras to identify hotspots and potential overheating issues.

✓ **Burn-In Testing**

- **Objective**: Stress test the circuit to identify early failures.
- **Techniques**:
    - **Extended Operation**: Run the circuit continuously for an extended period to detect reliability issues.
    - **High-Stress Conditions**: Subject the circuit to high temperatures and voltages to accelerate aging and identify potential failures.

✓ **Low-Level Signal Testing**

- **Objective**: Test circuits that deal with low-level or sensitive signals.

- **Techniques**:
  - **Signal-to-Noise Ratio Testing**: Measure the signal-to-noise ratio to ensure signal clarity.
  - **Shielding and Grounding**: Verify proper shielding and grounding to prevent interference and noise.

✓ **Frequency Response Testing**

- **Objective**: Evaluate how the circuit responds to different frequencies.
- **Techniques**:
  - **Frequency Sweep**: Apply a range of frequencies to the circuit and observe its response.
  - **Bode Plot Analysis**: Generate Bode plots to assess the circuit's frequency response characteristics.

✓ **Power Supply Testing**

- **Objective**: Ensure that the power supply meets specifications and provides stable voltages.
- **Techniques**:
  - **Load Testing**: Apply different loads to the power supply and measure voltage stability.
  - **Ripple and Noise Testing**: Measure the ripple and noise on the power supply output.

✓ **Component Testing**

- **Objective: Verify** the functionality and characteristics of individual components.
- **Techniques**:
  - **Component Testing**: Use a component tester or multimeter to check resistors, capacitors, diodes, transistors, and other components.
  - **Parametric Testing**: Measure specific parameters of components, such as gain in transistors or capacitance in capacitors.

✓ **Error Analysis**

- **Objective**: Identify and troubleshoot circuit errors or malfunctions.
- **Techniques**:
  - **Debugging**: Use debugging techniques to locate and resolve issues in the circuit.
  - **Fault Isolation**: Systematically isolate and test sections of the circuit to find the source of the problem

Points to Remember

- **Testing techniques** refer to the methods and procedures used to evaluate the functionality, performance, and reliability of electronic circuits or components
- Testing techniques for electronic circuits are crucial to ensure that they function correctly, meet design specifications, and are free from defects. Here are some commonly used testing techniques for electronic circuits:
  - ✓ Visual Inspection
  - ✓ In-Circuit Test (ICT)
  - ✓ Flying Probe Test
  - ✓ Automated Optical Inspection (AOI)
  - ✓ Functional Circuit Test
- After repairing a cell phone charger that is not producing the needed output power, various testing techniques can be used to ensure the charger functions correctly. Here are some key techniques:
  - ✓ **Multimeter Testing**
    - Voltage Measurement
    - Current Measurement
  - ✓ **Load Testing**
    - Constant Load Test
  - ✓ **Oscilloscope Testing**
    - Output Waveform Analysis
  - ✓ **Functional Testing**
    - Device Charging Test
    - Temperature Check
    - ✓ **Safety Testing**
    - Short Circuit Test

Application of learning 3.4.

At Elect Rotech Labs in Huye, you have just completed to implement a cell phone charger that is providing the necessary output power to charge a cell phone. Before the charger is returned to service, you need to apply appropriate testing techniques to ensure it is functioning correctly

Indicative content 3.5: Application of Circuit Troubleshooting Methods

Duration: 3 hrs

Theoretical Activity 3.5.1: Description of circuit troubleshooting methods

Tasks:

1: Answer the following question:

i. What does circuit-troubleshooting method mean?

ii. List at least 5 circuit troubleshooting method used when repairing electronic circuit

2: Provide the answers for the asked questions and write them on flipchart/papers.

3: Present the findings/answers to the whole class.

4: For more clarification, read the key readings 3.5.1.

5: In addition, ask questions where necessary.

Key readings 3.5.1: Description of circuit troubleshooting methods

1. Definitions

✓ **Circuit troubleshooting**

Refers to the process of diagnosing and resolving issues or malfunctions within an electrical or electronic circuit. This process involves identifying why a circuit isn't working as expected and then implementing corrective measures. The goal is to restore the circuit to proper functioning or to understand and repair faults that prevent it from operating correctly.

Circuit troubleshooting is the process of identifying and fixing problems within an electronic circuit

Circuit troubleshooting methods are also defined as the specific techniques and procedures used to identify, diagnose, and fix problems in an electronic circuit. These methods involve a systematic approach to finding where the circuit is failing and determining how to correct the issue.

2. Some circuit troubleshooting methods used when you are repairing electronic circuit:

✓ **Voltage Measurements:** This involves using a voltmeter to measure voltage across components to identify irregularities or failures.

- ✓ **Amperage Measurements/ Current measurements:** Ammeters help measure current flow through components, indicating if there's a deviation from the expected current.
- ✓ **Resistance Measurements:** Ohmmeters check the resistance in circuits, ensuring components aren't damaged or shorted.
- ✓ **Substitution:** Replacing components with known working ones to isolate whether a particular component is causing the issue.
- ✓ **Bridging:** Temporarily bridging a component or connection to bypass it to determine if the issue lies there.
- ✓ **Freezing:** Cooling specific components or areas with freeze spray to pinpoint thermal issues causing malfunctions.
- ✓ **Signal Tracing and Injection:** Using a signal tracer to follow a signal path or injecting a signal into the circuit to identify where it's lost or altered.
- ✓ **Component Testers/Test Lamps:** Using specific tools to test individual components (like diodes, transistors) or using test lamps to check for voltage presence.
- ✓ **Re-soldering and Adjusting:** Re-soldering poor connections or adjusting components to ensure proper contact and functionality.
- ✓ **Bypassing:** Creating temporary bypasses to check if a specific component or segment is causing the issue.

3. Importance of Circuit Troubleshooting

- ✓ **Ensures Functionality:** Helps ensure that electrical and electronic systems work correctly and reliably.
- ✓ **Prevents Damage:** Identifies and fixes issues before they cause damage that is more significant or failures.
- ✓ **Improves Performance:** Can lead to improved efficiency and performance of the circuit.

Overall, circuit troubleshooting is a crucial skill for anyone working with electronics, as it helps in maintaining and repairing systems to ensure they function as intended.

Points to Remember

- **Circuit troubleshooting** is the process of identifying and fixing problems within an electronic circuit.
- **Circuit troubleshooting methods** are also defined as the specific techniques and procedures used to identify, diagnose, and fix problems in an electronic circuit. These methods involve a systematic approach to finding where the circuit is failing and determining how to correct the issue.

Here there are some circuits troubleshooting methods used when you are repairing electronic circuit:

- ✓ Voltage Measurements
- ✓ Substitution
- ✓ Bridging
- ✓ Re-soldering and Adjusting

Application of learning 3.5.

At **Elect Rotech Labs** in Huye, you have just completed to implement a cell phone charger that is providing the necessary output power to charge a cell phone. Before the charger is returned to service, you need to apply all troubleshooting methods to ensure it is functioning correctly

Indicative content 3.6: Elaboration Of Electronic Circuit Implementation report

Duration: 3 hrs

Theoretical Activity 3.6.1: Description of electronic circuit implementation report

Tasks:

1: You are asked to answer the following question:

i. What does electronic circuit implementation report mean?

ii. List and explain at least 5 main elements of electronic circuit implementation report.

2: Provide the answers for the asked questions and write them on flipchart/papers.

3: Present the findings/answers to the whole class.

4: For more clarification, read the key readings 3.6.1.

5: In addition, ask questions where necessary.

Key readings 3.6.1: Description of electronic circuit implementation report

1. Definition

1.1. An electronic circuit implementation report

An **electronic circuit implementation report** typically refers to a document or output document generated after designing and building an electronic circuit. This report includes details about how the circuit was implemented

It is also defined as electronic **circuit implementation report** is a detailed document that summarizes the entire process of creating a working electronic circuit

2. Elaboration of electronic circuit implementation report

Creating an electronic circuit implementation report typically involves detailing the design, development process, components used, testing procedures, and performance analysis.

Here's a breakdown of what such a report might entail:

2.1. Introduction:

Brief overview of the project, its objectives, and the significance of the electronic circuit.

Description of the problem statement or the purpose of the circuit.

2.2. Design Specifications:

- Detailed specifications outlining the requirements of the circuit.

- Functionalities, performance expectations, and any specific constraints.

2.3. Circuit Design:

- Schematics and diagrams illustrating the circuit design.
- Description of the components used, their purpose, and the rationale behind their selection.
- Analysis of the design choices made (such as operational amplifiers, transistors, ICs, etc.).

2.4. Implementation Process:

- Step-by-step explanation of how the circuit was implemented.
- Prototyping details, if applicable.
- Challenges faced during the implementation and the solutions devised.

2.5. Testing and Validation:

- Testing methodologies employed to validate the functionality and performance of the circuit.
- Results obtained from simulations (if any) and practical testing.
- Comparison of expected versus actual performance.

2.6. Performance Analysis:

- Discussion on how well the circuit met the design specifications.
- Analysis of any discrepancies or unexpected behavior observed.
- Suggestions for improvements or modifications, if necessary.

2.7. Conclusion:

- Summary of the key points discussed in the report.
- Overall assessment of the success of the circuit implementation.
- Future recommendations or potential enhancements.

2.8. Appendix:

- Any additional technical details, code snippets, or supplementary information that supports the report.
- Ensure that the report is well-organized, includes clear diagrams and illustrations, and provides sufficient technical details for someone knowledgeable in the field to understand and potentially replicate the circuit.
- Remember, the depth and complexity of the report may vary based on the complexity of the circuit and the audience it's intended for (e.g., academic, industry, research, etc.).

Points to Remember

- An **electronic circuit implementation report** typically refers to a document or output document generated after designing and building an electronic circuit. This report includes details about how the circuit was implemented
- **It is also defined as** electronic **circuit implementation report** is a detailed document that summarizes the entire process of creating a working electronic circuit. It typically includes the following main elements:
  - ✓ Introduction
  - ✓ Design Specifications
  - ✓ Circuit Design
  - ✓ Implementation Process
  - ✓ Testing and Validation
  - ✓ Performance Analysis

Application of learning 3.6.

At Elect Rotech Labs in Huye, you have just completed to implement a cell phone charger that is providing the necessary output power to charge a cell phone. Before the charger is returned to service, you need to elaborate electronic circuit implementation report by including all necessary elements.

Learning outcome 3 end assessment

Written assessment

1. Answer by true or false

   A. Circuit fault refers to any undesired or abnormal conditions that occur within an electrical circuit, leading to a disruption or failure in its normal operation.
   B. Circuit fault refers to any desired or normal conditions that occur within an electrical circuit, leading to its normal operation.

2. List common electronic circuit fault.
3. The following are major testing techniques used when you are repairing electronic circuit EXCEPT:

   A. Visual Inspection
   B. In-Circuit Test (ICT)
   C. Flying Probe Test
   D. Diode measurement
   E. Functional Circuit Test

4. The following are safety measures to consider when repairing electronic circuit EXCEPT:

   A. Power Off and Discharge Capacitors:
   B. Work Area Safety
   C. Personal Safety Equipment
   D. Use the Right Tools
   E. Assemble electronic component

5. Complete the following using: **Accuracy, Reliability, Cost Savings, Reliability, Safety, Documentation:**

   A. **……………………** Ensures measurements are close to true values, preventing errors.
   B. **……………………** Builds confidence in measurement results and prevents faulty data.
   C. **……………………** Reduces waste and prevents expensive rework or repairs.
   D. **……………………** Ensures accurate measurements for critical applications, enhancing safety.
   E. …………………… Provides a record of equipment performance and adjustments, ensuring traceability

6. Match the column **A** to its corresponding identification to the column **B.**

Column A	Column B
1. Voltage Measurements	a. Ammeters help measure current flow through components, indicating if there's a deviation from the expected current.
2. Current Measurements	b. Ohmmeters check the resistance in circuits, ensuring components aren't damaged or shorted.
3. Re-soldering and Adjusting	c. Re-soldering poor connections or adjusting components to ensure proper contact and functionality.
4. Resistance Measurements	d. This involves using a voltmeter to measure voltage across components to identify irregularities or failures.

Practical assessment

QUICK TECH Ltd is a computer manufacturing company, located in RUGANDO special Economic zone, Kigali city. The company deals with manufacturing computer system hardware, such as desktops, laptops, laptop adaptors and peripherals. QUICK TECH Ltd have signed an agreement with AB College of education, to implement 100 Laptop adaptors for refurbished laptops, which need to be powered. The adaptors to be implemented must be designed so that they have to meet the following specifications; Input voltage: 220VAC, output voltage: 18VDC, output current: 4A. And they agreed to first identify laptop adaptor fault, use different circuit troubleshooting methods while implementing them after they must apply needed testing techniques to be sure that the adapters are working normally. As a manufacturing technician you are tasked to identify fault of those adapters, use all troubleshooting method, test whether those adapters are delivering outputs meet the specifications of the laptop adaptor to be used and make sure that you have elaborated circuit-implemented report and before Design their electronic circuit diagram

References

Circuits, A. A. (n.d.). *How to Build a Simple Circuit*. Retrieved from All About Circuits: https://www.allaboutcircuits.com/projects/how-to-build-a-simple-circuit/

Circuits, A. A. (n.d.). *Troubleshooting Circuits: Basics and Testing*. Retrieved from All About Circuits: https://www.allaboutcircuits.com/technical-articles/troubleshooting-circuits-basics-and-testing/

Digest, C. (n.d.). *Basic Electronics Projects for Beginners*. Retrieved from www.Circuit Digest.com: https://circuitdigest.com/electronic-circuits

Digest, C. (n.d.). *Top 10 Basic Electronics Troubleshooting Techniques*. Retrieved from Circuit Digest: https://circuitdigest.com/article/top-10-basic-electronics-troubleshooting-techniques

Digest, C. (n.d.). *Top 10 Basic Electronics Troubleshooting Techniques*. Retrieved from www.Circuit Digest.com: https://circuitdigest.com/article/top-10-basic-electronics-troubleshooting-techniques

Electronics-Tutorials. (n.d.). *Basic Electronic Circuits*. Retrieved from Electronics-Tutorials: https://www.electronics-tutorials.ws/blog/basic-electronic-circuits.html

Electronics-Tutorials. (n.d.). *Fault Finding in Electronic Circuits*. Retrieved from Electronics-Tutorials: https://www.electronics-tutorials.ws/blog/fault-finding-electronic-circuits.html

Gibilisco, S. (2016, February 4). *How to Read Circuit Diagrams for Beginners*. Retrieved from www.Instructables.com: https://www.instructables.com/How-to-Read-Circuit-Diagrams-for-Beginners/

Hill, P. H. (2024, September 21). *How to Read a Schematic*. Retrieved from www.All About Circuits.com: https://www.allaboutcircuits.com/textbook/direct-current/chpt-7/how-to-read-a-schematic/

Hill, P. H. (2024, September 21). *How to Read a Schematic*. Retrieved from www.All About Circuits.com: https://www.allaboutcircuits.com/textbook/direct-current/chpt-7/how-to-read-a-schematic/

Instructables. (n.d.). *Simple Electronic Circuits for Beginners*. Retrieved from www.Instructables.com: https://www.instructables.com/Simple-Electronic-Circuits-for-Beginners/

McComb, C. S. (2019, March 3). *How to Read and Understand Circuit Diagrams*. Retrieved from Circuit Digest: https://circuitdigest.com/article/how-to-read-and-understand-circuit-diagram

Monk, P. S. (2016, June 15). *Understanding Circuit Diagrams*. Retrieved from Electronics-Tutorials: https://www.electronics-tutorials.ws/schematic/schematic_1.html

END

RTB | RWANDA TVET BOARD

October, 2024